A New Cross-Country Measure of Material Wellbeing and Inequality:
Methodology, Construction and Results

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Abstract

This paper advances a new framework for defining a country's material wellbeing based on the distribution of consumer durables, building on the recent material wellbeing literature that calls for an increased focus on both the level and the distribution of consumption and wealth. Our framework is demonstrated using household-level data from the OECD PISA surveys, from which triennial metrics are constructed consistently for 40 countries since 2000. Comparisons with income-based alternative metrics suggest that our consumption-based measure captures important aspects of material wellbeing at both the micro and the macro level. Differences between the two approaches is shown to be associated with life-cycle smoothing, an important aspect that should be captured in material wellbeing estimates.

JEL codes

D31, D63, I31, O57

Keywords

Material wellbeing, quality of life, national accounts, cross-country analysis, distributions, inequality, household durables.

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1. Introduction

"Consumption is the sole end and purpose of production."

– Adam Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations*, 1776.

More than 200 years ago Adam Smith argued that consumption is the objective, production is simply the means. This principle is too often forgotten, with macroeconomic indicators of production enjoying a wide misinterpretation as welfare metrics in spite of their well-documented limitations in this respect (see Stiglitz, Sen and Fitoussi, 2009; hereafter SSF). There is therefore a need to more accurately quantify various aspects of wellbeing - a complex multidimensional concept determined by material living standards as well as, but not limited to, health, education, and environmental factors (SSF). Without downplaying the importance of non-material factors, which are increasingly informing living standards metrics (for example, see the Human Development Index, the OECD Better Life Index), our focus is on the measurement of material wellbeing - specifically, the wellbeing obtained from the consumption of goods and services.

We document a framework for measuring material wellbeing based on observed consumption patterns across households and across countries, and apply the framework to unit record data from 40 countries over the period 2000-2012 (obtained from the OECD's PISA survey). Our applications, which include household, country and 'global' level analysis, provide new information on the level and distribution of material wellbeing within and across countries. While our measures bear expected relationships with other material wellbeing measures, such as GNI per capita and the Gini coefficient of national income distributions, there are some substantive differences which indicate that our application of this framework yields new insights about the level and distribution of material wellbeing within and across countries.

Our measure is heavily influenced by the thinking espoused in SSF, particularly their key recommendations for the measurement of wellbeing. These include placing a greater focus on consumption and wealth whilst concentrating less on production, and accounting for their respective distributions. The first recommendation is consistent with the epigraph, while the focus on the level and distribution of wealth has become a major economic topic. Importantly, wealth is not a welfare metric in itself. Smith (1776) argues an individual's wealth is "*the degree in which he can afford and enjoy the necessaries, conveniences, and amusements of human life*." In this, Smith (1776) suggests that material wealth only matters to the extent it leads to useful consumption (Mueller, 2014), defining wealth as a welfare metric in a capabilities framework similar to Sen (1985).

The contribution of our study is two-fold. Firstly, motivated by both Smith (1776) and Sen (1985), we develop a framework for measuring household material wellbeing that satisfies the recommendations of SSF within a consistent capabilities framework. Specifically, we consider the annual flow of consumption services from a set of consumer durables within the home, which (under certain assumptions) approximates the welfare associated with these possessions at the margin.

Secondly, we apply this framework to the household-level data of the OECD's Programme for International Student Assessment (PISA) survey. The PISA survey aims to inform educational systems around the world by analysing the abilities and attitudes of 15 year old students from across 75 economies, with surveys conducted triennially beginning in 2000. Supplementary questions on the home environment were introduced to consider the determinants of educational achievement; this includes the presence of an array of cultural, educational and status goods, from which we define a household's material wellbeing (HMW). We then map HMW into three series: the Material Wellbeing Index (MWI) represents the country-year mean of HMW; the Atkinson's Inequality Measure (AIM) captures the degree of inequality in the country-year-specific HMW distribution[1]; and the Inequality-adjusted MWI (IMWI), which reflects the level of MWI which, if enjoyed by everyone, would maintain social welfare under certain assumptions. We present summary tables for each of these metrics, in both levels and changes, during both pre- and post-GFC periods, validate the measures through comparisons with income-based alternatives, and explore their relationship with other wellbeing measures.

The constructed measures have a number of strengths. First, in accordance with SSF, MWI and IMWI are consumption-based and wealth-focused, whilst AIM and IMWI capture distributional concerns. Second, the data we employ is freely-available independent data managed by the OECD, with significant undertakings to ensure the representativeness of the sample. Further, the PISA sampling design provides a strong element of demographic control – all units are a household with a 15 year old student – which improves the comparability over time and across countries. Of course there are drawbacks to this measure, including (i) truncation at the top of the distribution, and (ii) the assumption of interpersonal comparability in utility functions, although the latter is true for all aggregate indices, and our construction of the IMWI at least enables differing interpersonal value judgements to be accommodated.

[1] This inequality measure first appears in Atkinson (1970).

This is not the first study to proxy material wellbeing through the use of household durables; the most recent example is Smits and Steendijk (2014), which uses an asset based wealth index to evaluate the relative positions of households across developing countries. This is also not the first study to use PISA possession data to infer the socio-economic status of the respondents: both the Family Wealth Index and the Index of Economic, Social and Cultural Status are constructed from PISA data. However, the common approach to defining relative positions within this literature uses Principal Components Analysis - a data driven approach which produces an index devoid of absolute meaning. The metric defined in this paper differs substantially since we use market prices to weight the items to construct an absolute proxy for material welfare.

While it is difficult to validate any new metric, the evidence indicates that we are indeed capturing important aspects of material wellbeing. First, micro-level analysis shows our measure of household material wellbeing is positively associated with household income. Second, this relationship also holds at the national level, demonstrated by a strong association between our aggregate measure and Gross National Income per capita (GNIpc) in both levels and changes, albeit with some substantive departures. Importantly, multivariate analysis suggests that credit institutions are positively associated with the level of MWI for a given national income. This is a key result: our framework is consistent with consumption-smoothing behaviour and therefore represents a significant improvement to the measurement of material wellbeing in the presence of differing credit constraints between people and across countries.

Third, we consider cross-country convergence. The neoclassical (exogenous) growth hypothesis suggests that countries with lower initial levels of income per capita will enjoy higher subsequent rates of growth, as countries converge in income per capita. We find that countries with lower levels of MWI have higher subsequent growth. This holds both during the 2000-2009 global expansionary period, and during the 2009-2012 contractionary period, even when we condition on national income levels and growth.

Fourth, we consider distributional estimates using the Atkinson Inequality Measure (AIM), an individualistic, subgroup-consistent, measure of inequality that can flexibly accommodate different social preferences for inequality, based on Atkinson (1970). We find that our central estimate of household possession inequality is highly correlated with the Gini coefficient of national income distributions. Thus more unequal distributions of household resources are associated with more unequal income distributions. We use the micro-level data to examine 'global' inequality and provide results that support the contention of Milanovic (2012) that the world is becoming a more equal place; our results suggests this holds for household possessions as well as incomes.

The rest of this paper is structured as follows. Section 2 motivates our metric further, section 3 details the data used in this research, and section 4 describes the construction of our alternative indices. Section 5 discusses the cross-country levels and rankings of MWI across all periods. Section 6 presents validation information for the metric, section 7 discusses the relationship our measure has with alternative wellbeing metrics while section 8 presents sensitivity analysis to consider the robustness of our metrics. Section 9 concludes.

2. Motivating our Framework

In response to SSF, and in the context of Smith (1776), we develop a material wellbeing framework that reflects both consumption and wealth at the household level. This section lays out the motivation behind this framework and presents some related caveats.

The argument that living standards are a function of both consumption and wealth is partially based on considering the sustainability of consumption: the balance sheet influences one's ability to fund consumption in excess of income. Furthermore, the permanent income hypothesis indicates that today's consumption should be determined by today's wealth and income, as well as expectations of future income flows; thus, current consumption should be a better measure of lifetime material wellbeing than current income.

Importantly, material wellbeing is a multidimensional concept, so the question arises as to how one should aggregate across dimensions? Even when our focus is restricted to a small set of goods there are many ways to rank bundles. A simple option would be to consider rankings based on a mapping of consumption of multiple goods to a single focal good. However, Dowrick and Quiggin (1993) show that rankings based on a single good are sensitive to local price and preference differentials.

If an individual's utility function was observed, the relevant weight to use for aggregation would be inferred from comparative statics over utility. Unfortunately an individual's utility function is unknown to the researcher. However, in well-functioning markets, economic theory establishes a fundamental link between utility and price. Therefore if we observe prices, we can back out information on marginal utility.

To see this, consider the simple one-period consumer problem where the consumer derives utility from two observed goods, A and B, and some unobserved composite good, C. Let us denote the quantity of good j consumed as x_j, $j \in \{A, B, C\}$. Utility maximisation requires that a consumer allocates her expenditure across the three goods such that the marginal utility from obtaining an additional dollar is independent of the good on which it is spent. The optimal bundle (x_A^*, x_B^*, x_C^*) then satisfies the following condition.

$$0 \leq \frac{U_A(x_A^*, x_B^*, x_C^*)}{P_A} = \frac{U_B(x_A^*, x_B^*, x_C^*)}{P_B} = \frac{U_C(x_A^*, x_B^*, x_C^*)}{P_C} = \lambda \qquad (1)$$

where $U_j(x_A, x_B, x_C)$ is the partial derivative of the utility function with respect to good $j \in \{A, B, C\}$, evaluated at the consumption bundle (x_A, x_B, x_C), and P_j is the price of good j. The marginal utility per dollar evaluated at the optimal bundle is the shadow price, which we denote by λ. Now consider a first-order Taylor series approximation of the associated utility function at the point $(0,0,x_C^*)$, i.e. where consumption of the unobserved composite is at its optimal level but $x_A = x_B = 0$, about the optimal bundle (x_A^*, x_B^*, x_C^*). Solving the resulting approximation for $U(x_A^*, x_B^*, x_C^*)$ yields the following expression

$$U(x_A^*, x_B^*, x_C^*) \approx U(0,0,x_C^*) + x_A^* U_A(x_A^*, x_B^*, x_C^*) + x_B^* U_B(x_A^*, x_B^*, x_C^*) \qquad (2)$$

That is, utility at a point can be linearly approximated by the level of utility associated with the zero-observed consumption bundle, plus the additional utility obtained from another unit of each good evaluated at the observed bundle, multiplied by the bundle components. Substituting optimality condition (1) into (2) yields the following:

$$P_A x_A^* + P_B x_B^* \approx \frac{U(x_A^*, x_B^*, x_C^*) - U(0,0,x_C^*)}{\lambda} \qquad (3)$$

Thus, in this simple framework, observed expenditure approximates the difference in utility associated with optimal consumption of observed goods and no consumption of the observed goods, holding unobserved consumption constant at the optimal level, expressed in dollars through division by the shadow price. As such, we argue that the market value of consumption (the left-hand side of (3)) provides a useful measure of welfare. However we acknowledge that the measure is imperfect. Equation (3) makes the critique of Dowrick and Quiggin (1993) explicit; meaningful comparisons based on an expenditure metric requires that the prices consumers face, and their utility functions, are comparable.

Importantly, this paper focuses on goods which represent both wealth and consumption: consumer durables. These goods deliver annual flows of consumption services; however they also represent a store of wealth and allow consumption to be greater than income at any given point in time. As such, durable goods are only defined in a framework of multiple time periods. Graham and Oswald (2006) argue that wellbeing is a flow, rather than a stock. We adopt this definition, considering utility (or welfare) to be a function of the annual flow of consumption services that arise from asset possession in a given year. The approximation analogous to (3) under multiple time periods, which enables durable goods, is derived in Appendix 1 and appears as follows.

$$R_{A,t}x_{A,t}^{*} + R_{B,t}x_{B,t}^{*} = \left(r_t + \delta_A - \dot{P_{A,t}}\right)P_{A,t}x_{A,t}^{*} + \left(r_t + \delta_B - \dot{P_{B,t}}\right)P_{B,t}x_{B,t}^{*} \approx \frac{U\left(\theta_A x_{A,t}^{*}, \theta_B x_{B,t}^{*}, x_{C,t}^{*}\right) - U\left(0,0,x_{C,t}^{*}\right)}{\lambda_t} \quad (4)$$

where all previous definitions are maintained, along with t and j denoting time and durable good indexes, R denoting the rental cost of consumer durables, defined as the sum of the real interest rate r and the rate of depreciation on that durable δ, less the expected real capital gain $\dot{P_{j,t}}$. Thus the rental cost of consumer durables provides a useful monetary approximation of the difference in utility from the optimal bundle over the zero-durables comparison, holding non-durables consumption constant at the optimal (but unobserved) level $x_{C,t}^{*}$. Equation (4) informs the construction and interpretation of our material wellbeing metric, to be developed in Section 4.

Of course, the use of market prices to weight items is by no means novel; national income estimates have done so since Kuznets (1934). Furthermore, inclusion of a rental cost variable in GDP (a housing owner's imputed rent) has become widely accepted since System of National (1993). However the framework presented above rationalises the adoption of this methodology to other contexts, whilst making the interpretation explicit. As a result of the conceptual relationship with GDP construction, our metric is susceptible to a number of the common GDP critiques discussed in SSF: only goods for which prices exist can be included, prices may not reflect social value, and there are difficulties in capturing quality changes. This research does not attempt to make progress along these dimensions; our focus instead is to promote a framework capable of comparing household material wellbeing distributions based on possessions data, while acknowledging the caveats.

3. Data

Our primary data source is the Programme for International Student Assessment (PISA), a triennial survey of the scholastic abilities and attitudes of 15 year olds from around the world, run by the Organisation for Economic Cooperation and Development (OECD). Whilst the key aim of PISA surveys is to examine the attitudes and abilities of students around the world, our focus is limited to the supplementary questions introduced to assess the relationship between educational achievement and the home environment. Specifically, students are asked a set of binary questions regarding the presence of different possessions within the home, ranging from goods with low monetary value, such as books, to more valuable attributes, such as whether the student has their own bedroom (henceforth referred to as the possession 'own room'). Another set of questions considers how many units (incrementally ranging from 0 to '3 or more') of a given possession are present in a student's home, with the set restricted to consumer durables such as cars and computers. The consistency of these questions over time and across many countries in the PISA survey produces an appealing dataset with which to apply our methodology of constructing a measure of household material wellbeing.

The five currently available waves of household-level PISA data are combined within a multi-level repeated cross-section design that enables distributional analysis and aggregate comparisons across countries and periods. Repeated cross-sectional analysis requires comparability in the units over time. Given that the survey is completed by 15-year old students, the survey features a strong element of demographic control for comparisons across the two dimensions. We also require time-invariant country borders for aggregate comparisons.[2] The survey design does not guarantee that all household characteristics will be held constant across time and space; for example, the characteristics of a country's representative respondent will likely depend on whether the school-leaving age is below 15 or not, whilst the documented ageing of parents at time of first birth and shrinking of family sizes over time could bias the evolution of our material wellbeing measure upwards.

The inaugural PISA survey was conducted in 2000 with respondents from 43 countries; since then students from more than 70 economies have participated in at least one survey. Table 1 details the number of responding students, by economy and year. The country-year specific sample sizes range between 175 respondents in Liechtenstein in 2000 and 38,250 in Mexico in

[2] We did observe the transition of Serbia and Montenegro into separate states in our data. While this could have been accommodated through a weighted pooling of the post-2005 data for both the Republic of Serbia (SRB) and the Republic of Montenegro (MNE), because none of these countries were observed in 2000 they would have been left out of our analytical sample regardless.

2009, with the majority of country-year respondent counts between 4000 and 6000. These moderate to large sample sizes should reasonably reflect the underlying distributions of 15 year old students in each country. The analytical sample of countries to which we restrict our attention in this study are those for which there is data on all possession questions in the years 2000, 2009 and 2012, selecting on these years so that we may analyse aggregate changes over periods with different global economic cycles.[3,4] Table 1 shows that 42 of the 43 countries surveyed in 2000 also participated in 2009 and 2012. However, Israel did not have any responses regarding the number of bathrooms or 'own room' in 2012. Further, there is no information regarding dishwasher possession available for Peru in 2000. As such, these two countries are dropped from the analytical sample and we end up with a balanced aggregate sample of 120 country-year pairs, composed of 794,362 independent individual student responses - the ISO codes of the corresponding economies are bolded in the table for ease of identification.

The set of possession questions asked consistently across all waves defines the subset of resources that are taken to contribute towards material wellbeing in this paper. These goods feature as the rows of Table 2, partitioned by question type (binary or multiple response). We report four summary statistics for each possession: the proportion of possession observations missing, the mean possession rate across all country-year observations, the standard deviation of country-year specific mean possession rates (i.e. across-country variation in means), and the mean country-year specific standard deviation of possession rates (i.e. mean of within-country variation). Column 2 reveals low levels of missing responses across all goods, ranging from 1.7% to 3.9%. Across all possessions, just 8.5% of respondents in our analytical sample report a missing response, with a conditional mean of 4.8 missing possession responses among these respondents. To reduce the bias from potentially non-random missing observations we construct a complementary dataset (which we use exclusively in our analysis) via multiple imputation by chained equations. For each country-year pair we estimate possession counts as a system of equations, which allows for correlated effects across equations, where the count of each specific good is a function of the count of all other goods as well as subnational fixed effects, the student's household composition and the educational attainment and labour market outcomes of their parents. This Bayesian

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[3] Whilst 43 economies appear in the first wave of PISA only 32 of these economies actually tested their students in 2000. Students from the remaining 11 countries (ALB, ARG, BGR, CHL, HKG, IDN, ISR, MKD, PER, ROU, THA) were surveyed in 2002. In the analysis that follows we shall refer to these data as though they were realised in 2000, however we construct 7 year changes to 2009 where applicable and make comparisons with alternative 2002 metrics whenever possible. Further, 64 economies originally participated in the 2009 wave with ten additional participants reporting data based on surveys conducted in 2010. However, because the latter countries would not be included in our analytical sample due to no observations in 2000 or 2012 they are ignored in this study.

[4] We ignore the intervening waves as no multiple possession responses are available for 2003, nor for the number of bathrooms in 2006.

imputation model then substitutes the predicted values for the missing responses and repeats the process for a total of 8 iterations, an iteration count consistent with the guidelines of White, Royston and Wood (2011). The binary responses are estimated via logit regressions, whilst the multiple variables are estimated via ordered logistic regressions.

Column 3 of Table 2 documents the mean response of each possession question, pooled across all country-years.[5] Amongst the binary question possessions we find a clear division in ownership rates between desks, dictionaries, 'own room', study places and textbooks (which are all in excess of 79%), and the majority of remaining possessions – artwork, classic literature, dishwashers, educational software, poetry - which have a penetration rate between 51% and 59%. The exceptions is internet access, which is enjoyed by 71% of respondents. In terms of the multiple response possessions, we find that across all country-year respondents there was an average of more than 2 bathrooms, cars and computers per household, and more than 1.7 cell phones and televisions per household.

Now consider the across-country variation in mean possession rates (Column 4). Cars, computers and cell phones have the highest standard deviation of country-year specific mean possession rates, in excess of 0.5. We note that the variation in all binary response mean possession rates is less than the variation in all multiple response possession counts, which partly follows from the reduced level of censoring on the underlying distributions. Finally, consider the mean level of within-country variation in possession counts (Column 5). We find that for all possessions (except cell phones) there is a greater degree of variation within countries, than between country means. The difference in variation is greatest amongst binary response possessions, suggesting such variables may be more important in determining within-country differences, whilst the multiple response variables may be more important in considering cross-country differences.

The supplementary data for this project relates to the prices and lifespans of the PISA possessions, required to calculate the weights (imputed rental expenditures) for aggregation; these data are reported in Table 3. Column 1 lists the data source used to obtain possession prices[6]. The second column indicates that the lifetime benefit of a possession, as implied by price, varies widely across our set, from $30 for a book to almost $21,000 for an additional bedroom. We note a clear split in prices; 11 of our possessions are valued at less than $1000 whilst four of the remaining five possessions are valued at more than $6000. Note that the prices used in this paper are both time

[5] As described in section 4, we treat responses of '3 or more' in the multiple possession categories as a response of 4.

[6] The price of housing characteristics ('own room', study place, bathrooms) are obtained using Sirmans et al (2006) meta-analysis of hedonic characteristics in conjunction with house price data from the FRED database. The 'price' of cars reflects the expected loss of value for a new Toyota Corolla over the useful life over a car (4 years).

and country invariant (using US 2014Q2 prices as the reference). We do so to reflect the objective benefit an asset is capable of delivering, motivated by the capabilities approach of Sen (1985), abstracting from the variation around this reference point in order to isolate the impact of different possession distributions. In addition to the opportunity cost of a possession, the loss of value over time represents an important component of a possession's rental cost. We use the estimated useful life of a possession, as reported by New Zealand's Inland Revenue Department to annualise the prices; estimated possession lifespans appear in column 3 whilst the calculated annualised rentals (which are assumed to be equal to the annualised prices because inflation and interest rates were near zero during the reference quarter) appear in column 4.

4. Index Construction

To understand the empirical implications of our framework we examine its application to the household-level PISA dataset; the methodology and assumptions employed in this application are discussed below.

One difficulty in inter-household comparisons, and in the aggregation of household information to the national level, is that measures across household units should be comparable. Differing household sizes violates this requirement. To obtain the required comparability across households in the presence of different household sizes we choose to equivalise the flow of material wellbeing to the household by household size.[7] Unfortunately, household size was not asked specifically within PISA surveys, however we can construct an informative lower bound by aggregating a student's responses to questions regarding the presence of relations. Specifically, each student is asked whether they usually live with someone in the following relationship categories: their mother (including stepmother or foster mother), which we denote as m; father (including stepfather or foster father), f; any sisters, s; any brothers, b; any grandparents, g; or any others, o. These variables take the value of one if the student states their household features at least one member of the corresponding group, and zero otherwise, thus the greatest lower bound for the household size of student i in period t, denoted $\widehat{N}_{it}$, is defined as one (the student) plus the sum of each response.

$$\widehat{N}_{it} = 1 + m_{it} + f_{it} + s_{it} + b_{it} + g_{it} + o_{it} \tag{5}$$

[7] Note that in considering the equivalised flow of wellbeing we should only discount the benefit of rivalrous goods; given artwork often appears in common areas we treat this category as non-rivalrous, however all other possessions are treated as rivalrous.

Given a measure of household size there are a number of possible equivalisation methods, all of which rely on dividing household flows by an equivalence scale. The equivalence scale used in this study is the square root of observed household size, $\widehat{N}_{it}$. We choose this equivalisation approach because (i) the adult-child composition of the household cannot be inferred reliably (information which is required for the prominent alternative OECD methods), (ii) when true household size is under-observed, as may be the case in PISA, the difference between the true equivalence scale and the observed equivalence scale is lower under this method than both OECD methods for all households with an observed size greater than 2 (see Appendix 2 for the proof), a requirement which is satisfied for almost 95% of our respondents, and (iii) this is the recommended scale when using the Luxembourg Income Study (Lefèbvre, 2007), a well-established cross-country database of an alternate measure of household material wellbeing.

The presence of relations, in combination with whether the student has their own bedroom, also allows us to produce a meaningful lower bound on the household's total number of bedrooms – this is likely a better measure of household wealth than whether the 15 year old student has their own room. We estimate the number of bedrooms under the assumption that homes are not crowded (according to Canadian National Occupancy Standards; see Canadian Mortgage and Housing Corporation, 1991) along with some other minor assumptions.[8] Thus the estimated minimum number of bedrooms is defined as

$$q_{itb} = or_{it} + \max\{m_{it}, f_{it}\} + s_{it} + b_{it} + g_{it} + 0.5o_{it} \tag{6}$$

where q_{itb} denotes the number of bedrooms in student i's household in period t, or is a dummy variable corresponding to whether or not the student has their own room, and all other expressions are as above.

We now define the equivalised household material wellbeing (HMW) of household i in period t as the weighted sum of possession counts, including the number of bedrooms, where the weights are the associated rental costs, equivalised by household size for all rivalrous goods. The quantity of the binary response possessions is equal to one if the student declares the asset is present in their home, and zero otherwise. The quantity of multiple response possessions is given for responses "zero", "one" and "two"; we treat the response "three or more" as though the

[8] Specifically, we assume potential couples living together share a bedroom (meaning there is no more than one mother- and father-figure present, together whom share a room), brothers and sisters do not share a bedroom (this is a simplification because we do not know the age of siblings as only the sharing of a bedroom between opposite-sex siblings where at least one is over the age of 5 is considered crowding), any grandparents present are from just one side of the family and thus share just one bedroom, and half of any 'others' present have their own room. We arrive at the final assumption by noting that some of the 'others' will share, for example young relatives who may share a bedroom with young household members or older individuals whom are in a relationship with another household members, whilst some would require their own room, such as extended relatives or friends.

household has four of these possessions - we assume the latter since three must be an underestimate of the conditional average within that group, and we choose the next integer in the sequence[9]. That is,

$$HMW_{it} = \frac{1}{\sqrt{\widehat{N}_{it}}} \sum_{d \in R} q_{itd} P_d\left(r + \delta_d - \dot{P}_d\right) + \sum_{d \notin R} q_{itd} P_d\left(r + \delta_d - \dot{P}_d\right) \quad (7)$$

where d is an index of items over the set of PISA household durables, R is the subset of PISA possessions which are rivalrous, q is quantity, P is price, r is the real interest rate, δ is the depreciation rate (defined here as the reciprocal of the possession's lifespan), and $\dot{P}$ is the associated real expected price change. We assume that the latter is zero (since there is no basis for predicting whether the expected nominal price change is greater or less than the rate of inflation). Furthermore, given that prices are obtained from 2014 US data, a time when the nominal interest rate was approximately equal to the inflation rate, we assume $r = 0$ in our calculations, reducing the possession weights to annualised prices.[10]

Note that this framework adopts country and time invariant rental costs in defining welfare, intended to reflect the benefit an asset is capable of delivering in the spirit of Sen (1985) whilst isolating the impact of different possession distributions. Dowrick and Quiggin (1993) express concern in ranking consumption bundles by international prices when local prices or preferences differ, arguing that comparisons by international prices may not reflect the choice set faced by local consumers. This concern is valid, and we explore the robustness of our results to different price assumptions in Section 8.

Another caveat in our index construction is that we are unable to consider differences in quality across time or space. Because we do not know the extent to which quality differs, we cannot discount rental weights to reflect quality. Instead, for instance, we assume that a cell phone in 2000 yields a comparable annual benefit to its 2012 counterpart, and a bedroom in Albania is equivalent to a bedroom in the United States, whilst conceding this is unlikely to be true. Again, one can motivate this assumption, at least in part, by Sen's capabilities approach (e.g. a car offers a transportation service whether it is a Corolla or a Ferrari).

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[9] Note that if the distribution of (unobserved) non-truncated '3 or more' possession responses is triangular and the maximum non-truncated response is 6 then the conditional mean would be exactly four; if the maximum non-truncated response were five or seven then the mean would be 3.66 and 4.33, respectively, implying that 4 is a reasonable estimate to use.

[10] Note that there exists an upper bound to our calculated measure; household MW cannot exceed $13,350.08 (which corresponds to a one-person household with the maximum observed possession counts across all binary and multiple response possessions). Importantly, however, we do not observe a household with all possession counts at the maximum observable level.

In summarising within-country welfare, we note that possession counts are capped at moderate levels, thereby reducing the presence of outliers. As such, a reasonable measure of central tendency is the mean across a country's households, a metric we term the Material Wellbeing Index (MWI) and defined as follows.

$$MWI_{ct} = \frac{1}{N_{ct}} \sum_{i \in c} HMW_{it} \tag{8}$$

where c is a country index, N_{ct} is the number of students surveyed in country c in period t, and HMW_{it} is defined in (7).

Whilst comparisons of means is informative, a major focus of this study is to describe the associated distributional differences. As such, we seek a measure of the equality of the underlying distribution. The Gini coefficient has been previously promoted in related literature (Sen, 1973; Hicks, 1997); however Foster, López-Calva and Székely (2005) note that the Gini coefficient is not subgroup consistent. For that reason a generalised mean of the form of Atkinson (1970) was promoted, which was later adopted in the construction of the Inequality-adjusted Human Development Index by Alkire and Foster (2010). We follow this methodology, which has the added benefit that Atkinson's framework flexibly allows for a range of value judgements regarding society's inequality aversion through the free parameter ε. Accordingly, our principal inequality summary statistic is the Atkinson Inequality Measure (AIM), defined as follows

$$AIM(\varepsilon)_{ct} = \begin{cases} 1 - \left[\dfrac{1}{N_{ct}} \displaystyle\sum_{i \in c} \left(\dfrac{HMW_{it}}{MWI_{ct}} \right)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} & \text{for } \varepsilon > 0, \varepsilon \neq 1 \\ 1 - \left(\displaystyle\prod_{i \in c} \dfrac{HMW_{it}}{MWI_{ct}} \right)^{\frac{1}{N_{ct}}} & \text{for } \varepsilon = 1 \end{cases} \tag{9}$$

where ε is society's constant relative inequality-aversion parameter, and c and t are country and time indices respectively. Thus inequality is a non-linear aggregation of deviations around the mean. Note that under perfect equality, i.e. $HMW_{it} = MWI_{ct} \; \forall \; i \in c,$ we have $AIM(\varepsilon)_c = 0 \; \forall \; \varepsilon > 0$, whilst the measure is increasing in the concentration of resources.

There are some reasons why our inequality metric could understate inequality relative to broader income/expenditure measures, and relative to the true underlying values of household wealth. For instance: (i) we cannot consider value differences within a possession category, (a Corolla is equal to a Ferrari); (ii) the list of possessions does not include expenditure on categories for which the richer spend more, such as financial services or air travel; and (iii) the number of each possession within the household is truncated. However, the high weight attached to certain consumer durables in our analysis may alleviate this concern. Further, we do not observe expenditure on goods with low income-elasticity of demand (e.g. petrol), the omission of which leads to higher inequality estimates.

Our Inequality-adjusted Material Wellbeing Index (IMWI) combines the previous two metrics to describe central tendency and distribution simultaneously. Specifically, we multiply the mean index by one minus the inequality measure.[11] That is,

$$IMWI(\varepsilon)_{ct} = MWI_{ct}(1 - AIM(\varepsilon)_{ct}) \tag{10}$$

A nice interpretation for $IMWI$ and AIM follows from equation (10): $IMWI$ is the level of material wellbeing which, if enjoyed by all households, would leave social welfare the same as that under the current distribution, whilst AIM is the proportional difference between $IMWI$ and MWI. These three metrics are used in the following sections to comment on various aspects of material wellbeing.

5. MWI, AIM and IMWI Values and Rankings

Table 4 reports the MWI value for each country-year, as well as the annualised inter-period growth rates and associated rankings. We find the USA ranks highest on MWI values across all years, with an annual equivalised flow of $4,588 in 2000 and $5,075 in 2012. Other Anglo-Saxon settler countries (AUS, CAN, NZL) also rank highly across all years, whereas the large economies of Germany, France and Great Britain sit near the middle of the rankings. Economies in Eastern Europe, Asia and Latin America are mostly towards the bottom of the MWI distributions, while Indonesia (IDN) ranks the lowest on MWI across all years with an initial level of just 31% of the USA's MWI.

Ireland rose 14 places in the MWI rankings between 2000 and 2009, reflecting high absolute growth during the global economic expansion, whilst Japan fell by 8 places over the same period due to more modest growth. However these are relatively extreme changes: rankings do not change by more than 3 places in either direction between 2000 and 2009 for 26 of the 40 countries considered. Rankings are even more stable between 2009 and 2012 with only 3 counties experiencing a shift in relative position by more than 3 places: Iceland fell down the rankings by 6 places, whilst Liechtenstein and Spain rose by 5 and 4 places, respectively.

[11] This is analogous to the equally-distributed equivalent of Atkinson (1970).

We can also compare growth rates over time. Across all countries, the annualised MWI growth between 2000 and 2009 averaged 2.67%, ranging from -0.56% in Hong Kong to 5.57% in Russia. In contrast, the average annualised growth rate between 2009 and 2012 was just 1.04%, representing less than one half of the earlier period's average annual growth rate, with values ranging between -1.72% in Iceland to 5.98% in Hong Kong. That MWI growth was greater during the global economic expansion (corresponding closely to our 2000 to 2009 period) than the period following the global financial crisis suggests that there is a relationship between consumption and income-based welfare measures, which we investigate further in section 6.2. Similarly, we note that MWI growth is relatively low and tightly bound for countries with high levels of MWI, whilst countries with low initial levels of MWI enjoy a higher average growth rate. This observation motivates the investigation of MWI convergence across countries in section 6.3.

Table 5a details the country-year levels of our central estimate of inequality over material wellbeing, the Atkinson's Inequality Measure (AIM), with inequality aversion set equal to one.[12] The table also reports the relevant country-year rankings for both AIM(1) and the Gini Coefficient of the HMW distribution, where a country-year ranking of 1 indicates the lowest level of inequality among observations.[13] Finally, the table details the (annualised) rate of inter-period AIM changes, as well as the cross-country rankings for inter-period AIM and Gini coefficient changes.

We find some broad patterns in AIM(1) across all years: Nordic countries (DNK, NOR, SWE, ISL, FIN) enjoy some of the lowest levels of inequality, Anglo-Saxon countries sit near the middle of the distribution with moderate levels of inequality, and Latin American and Eastern European economies are some of the most unequal. Specifically, we find that Iceland was the most equal country by AIM(1) in 2000, with a value of just 0.035, implying that the mean level of resources required under an equally-distributed constant-welfare allocation would be just 3.5% less than that arising from the current distribution. At the other extreme is Mexico, whose distribution in 2000 was characterised by an AIM(1) that is almost four times greater than that of Iceland.

The global economic expansion coincided with reductions in inequality for 35 of our 40 countries between 2000 and 2009, whilst the mean level of AIM decreased from 0.063 in 2000 to 0.050 in 2009; at the end of that period, the Netherlands had the lowest levels of AIM(1), at 0.022, whilst Mexico remained in 40th position. Inequality continued to fall on average during the 2009-2012 period, with the mean AIM(1) value at 0.046 in 2012; however the rate of reduction was

[12] We focus on the results for ε=1, as it lies in the middle of the conventional interval for such parameter values (see Creedy, 1996), however Tables 5b and 5c provide analogous results for the $\varepsilon = 2$ and $\varepsilon = 3$ cases, respectively.

[13] The Gini coefficient values generally sit around 0.2, a value considerably smaller than measures associated with alternative indices, which often range of 0.4-0.6, consistent with the discussion in Section 4.

slower over this contractionary period and fewer individual countries enjoyed reductions in AIM over this latter period (29 of the 40). Latin American economies (BRA, ARG, MEX) enjoyed relatively large inequality reductions during the global contractionary period. Nevertheless, Mexico remained the most unequal society by AIM(1) in 2012.

The AIM(1) ranking of 63 (out of 120) country-year observations is the same as their HMW Gini Coefficient rankings, whilst just 5 observations have rankings that differ by more than two places. A Spearman rank correlation test comfortably rejects the null of statistically independent series at all conventional significance levels.[14] Thus our preferred inequality metric largely replicates orderings based on the common alternative.

Now consider the country-year mean and distribution simultaneously via the Inequality-adjusted MWI (IMWI), recalling that this is the level of MWI which, if enjoyed by all equivalised households, would yield the same level of social welfare as that under the current allocation. Table 6 reports the IMWI values for each country-year, as well as the annualised inter-period growth, plus rankings, using an inequality aversion of $\varepsilon = 1$.[15]

As with the MWI, the USA remains at the top of our social welfare measure across all years in spite of moderate inequality levels, whilst Indonesia again ranks lowest across all years due to both low average resources and high levels of inequality. To consider how rankings differ between MWI and IMWI(1) more systematically, examine the scatterplot comparison of rankings across measures, by year, in Figure 1. With an inequality aversion of $\varepsilon = 1$, we find that the rankings across these two metrics is equivalent for 60% of country-year observations, whilst just 2 of the 120 country-year observations change by more than 2 places in either direction (Mexico and New Zealand in 2000). This is because the relative differences in MWI generally exceed the absolute differences in AIM(1). This consistency across the two measures encourages us to simplify the following analysis and focus upon the MWI, since broadly consistent results would follow from using the IMWI. However, we note that AIM is a nonlinear function of ε, thus the social welfare penalty for a given distribution of resources is increasing in inequality aversion; we find MWI rankings differ from IMWI(3) rankings by two or more places for 58 country-year observations, whilst rankings are equivalent for just 29 observations.

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[14] The rank (Spearman) correlation coefficient between AIM(1) and the Gini coefficient, for the years 2000, 2009 and 2012, is 0.9955, 0.9951, 0.9940 respectively.

[15] Consistent with the analysis of inequality, we focus only on the results for ε=1, as it lies in the middle of the conventional interval for such parameter values (see Creedy, 1996), however Tables 6b and 6c provide analogous results for the $\varepsilon = 2$ and $\varepsilon = 3$ cases, respectively.

6. Validation of Material Wellbeing Metric

In this section we evaluate the validity of our measure through comparisons with related measures and we explore explanations for the deviations between our material wellbeing measure and other measures.

6.1. Household-level Analysis

SSF emphasised the importance of the household perspective in measuring material wellbeing, where material wellbeing is enhanced by income, consumption and wealth. Our measure is both consumption-based and wealth-focused, so here we consider the consistency between our metric and the excluded category: household income. Unfortunately, the income data available in PISA is imperfect. Firstly, income data is available only through the parental questionnaire, a supplementary questionnaire which was first introduced in 2006 and which relatively few countries have chosen to administer subsequently.[16] Secondly, household income is expressed as a categorical variable, with bins defined relative to the national median, and it is therefore imprecisely observed.[17] Nevertheless, the normalisation of income around the country-year specific median allows us to pool household-level observations from across countries with different median incomes and consider how the distribution of HMW (normalised relative to country-year specific MWI) is related to relative income positions.

This relationship is analysed through the box plots of relative HMW by relative income categories, for 2009 and 2012 separately, provided in Figure 2. As expected, with just one exception, we observe all parts of the distribution of relative HMW are increasing in relative income.[18] Thus, individuals with higher income levels tend to have higher levels of durables on average. However we also note the considerable overlap in the relative HMW distribution across relative income categories. This indicates that we have not simply constructed a linear transformation of income. Rather our metric contains considerable additional information on consumption services. This outcome is what we would expect since standard theory suggests that consumption should be smoother than income over the life-cycle; for instance, transitory low income in one year may still be accompanied by high consumption if lifetime income is high.

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[16] Only 16 of the 57 economies which administered a PISA student survey in 2006 also administered the parental questionnaire, whilst just 11/65 and 15/68 did so in 2009 and 2012, respectively.

[17] Households report whether their combined income is (i) less than 50% of the national median, (ii) between 50% and 75% of the national median, (iii) between 75% and 100% of the national median, (iv) between 100% and 125% of the national median, (v) between 125% and 150% of the national median, or (vi) greater than 150% of the national median.

[18] The sole exception is the upper adjacent value of HMW for the lowest relative income category in 2012.

6.2. Cross-country Comparison with GNIpc

At the aggregate level, we compare MWI to purchasing power parity (PPP) adjusted Gross National Income per capita (GNIpc). Figure 3 plots the cross-country relationship between the natural logarithms of MWI (denoted lnMWI) and GNIpc (lnGNIpc), by year, for our balanced panel of countries, (the log-log relationship reflects our expectation of a relative, as opposed to an absolute, relationship between income and material wellbeing). The chart shows a strong positive nonlinear relationship between the two measures across all years. The observed nonlinearity of MWI in relation to income is consistent with cross-country analysis of alternative wellbeing measures and income (Grimes, Oxley and Tarrant, 2012). However, it may also follow from the existence of an upper bound on MWI, discussed in Section 4. We find that a quadratic regression on lnGNIpc (excluding Hong Kong) explains more than 80% of the variation in lnMWI in each year; the fitted line from each regression is overlaid in the figure.[19] Note that the curvature of the fitted line is increasing over the period; this is consistent with an upper bound on our measure, so that as countries get richer over time their consumption of the surveyed durables does not increase at the same rate. Nevertheless we find that higher income per capita countries tend to have higher levels of household durables on average, again indicating that we are capturing important aspects of material wellbeing at the aggregate level.

Identifying a static cross-country relationship is useful, however the above analysis cannot rule out some fixed country-specific factor explaining the link. Stronger conclusions can be drawn from identifying a dynamic relationship; that is, whether changes in income and MWI are related. To examine the dynamic relationship between MWI and GNIpc, we chart the annualised changes in lnMWI and lnGNIpc in Figure 4. We observe the strong expansion of the Russian economy over the entire period, as well as the contraction of the Portuguese, Irish and Greek economies following the GFC, and we find that these experiences were reflected in changes in household durables also. Across all three panels, we observe a positive cross-country relationship between the growth rates in national income per person and MWI; thus economies with strong growth in national income during the period have also tended to enjoy a simultaneous expansion in household possessions. This indicates that there is a fundamental link between the measures, providing strong evidence that we are indeed capturing some component of material wellbeing.

[19] Hong Kong (HKG) is a clear outlier in this relationship across all years. This is almost entirely driven by the very low car ownership rates (at just 0.076 cars per equivalised household) among respondents, in spite of more moderate national income. This low car ownership rate is similar to World Bank national estimates, adding credibility to the representativeness of the PISA survey.

The result (in Figure 4) that for any given rate of GNIpc growth there can be quite different growth rates in MWI again indicates that our measure is picking up cross-country variability in material wellbeing that is not being fully reflected in per capita income growth.

The static and dynamic link between income- and our consumption-based measures of material wellbeing at the cross-country level is clear. However, in spite of the strong relationship between MWI and GNIpc in levels, we noted some variation around the trend. For example, New Zealand and South Korea have similar levels of national income per capita towards the end of the period, yet their levels of household possessions differ substantially. We also note that a number of Anglo-Saxon settler countries tend to enjoy high levels of MWI, for a given GNIpc, whilst some Latin American economies have lower levels of possessions than would be predicted by their income. To understand which additional factors explain MWI we can regress MWI on GNIpc and a set of additional variables. From standard theories, we consider that there are at least four processes which may explain the deviations between MWI and GNIpc.

First, income inequality can affect MWI for computational reasons: an increase in the concentration of income, holding average income constant, should increase the consumption of those above the upper-bound (which will not be recorded) and reduce the resources to those below (which will be recorded). This will result in a lowering of observable MWI for a given level of income. Furthermore, greater income inequality can skew the quality distribution of possessions, leading to an underestimation of MWI for a given GNIpc. For example, high income households are more likely to own a Ferrari, while all cars are treated as Corollas in our analysis. As such, MWI tends to truncate wellbeing flows at the top of the distribution, a truncation that is likely to be increasing in income inequality. Thus we include the Gini coefficient of household incomes, obtained via the World Bank and OECD databases and discussed in Section 6.4, as a regressor in the regression (denoted as Gini).

Second, an individual's consumption can differ from income at a point in time due to access to credit, enabling consumption smoothing over the life-cycle. This effect can feed through to the aggregate. To assess the extent to which the deviations between MWI and GNIpc may be explained by consumption smoothing we focus on the effectiveness of national institutions to facilitate credit. This process is captured by including the World Bank's Strength of Legal Rights Index, a series which captures the effectiveness of collateral and bankruptcy laws in facilitating business lending, as a regressor (denoted as Credit).[20,21]

[20] This annual series is only available for 2004 onwards; the level in 2000 is approximated by the 2004 value.
[21] While the credit series is for business, rather than household, access to credit, we expect the two will be correlated. Furthermore, to the extent that there is endogeneity in the consumer credit-consumption relationship, the inclusion of business access to credit can be considered as an instrument for consumer credit access.

Third, a nation's demographic composition may help explain the deviation of a country's MWI from that predicted by the regression of log MWI on log GNIpc. This is due to the demographic control inherent in MWI, a strength of this measure relative to measures such as GNI or GDP for cross-country analysis. One such demographic characteristic which influences national income is the share of the population of working-age.[22] This process is captured by including the country-specific percentage of the population aged between 20 and 65 (using data obtained from United Nations total population figures, denoted Demog).[23]

Finally, government social expenditure (for example, unemployment insurance) can reduce the impact of negative income shocks, by raising consumption relative to income for affected households, which will raise MWI for a given level of GNIpc given the non-linearity in the MWI-GNIpc relationship. This mechanism is analysed by including the log of government subsidies and transfers per capita, derived from World Bank data and denoted as lnTranspc.

Table 7 presents the associated regression analysis of these four potential explanations for non-income determinants of MWI. Columns 1-3 detail the results of the quadratic regression of lnMWI on lnGNIpc, by year, drawn as the fitted lines in Figure 3. The strong positive relationship is clear, with impressive explanatory power across all years although coefficients do vary between years, most noticeably between 2000 and 2009. Columns 4-6 include all factors described above as additional covariates in the quadratic regression, by year. Finally, columns 7-9 restricts our attention to the set of factors which are statistically significant in at least one year.

Given the strong explanatory power of the 'simple model', as well as the limited degrees of freedom, it is unsurprising that the additional regressors of the 'full model' do not substantially affect the results. We find that lnGNIpc remains a strong predictor of log MWI in the full model, although the quadratic term is individually statistically significant only in 2009.[24] The only additional regressor which is significant is Credit, which is statistically significant in both 2000 and 2009; although the coefficient is insignificant in 2012 its sign is consistent with the other years. We find that, in 2000 and 2009, economies with greater (business) access to credit enjoyed higher levels of MWI, other factors constant. This outcome is consistent with the importance of access to credit to facilitate consumption smoothing. The households in our survey all have a 15 year old in the household, while housing ('own room', study room and bathrooms) play a prominent role amongst our possessions. Households that have good access to credit can bring forward consumption of housing services, and thus may have higher material wellbeing on our measure than do households

[22] A good discussion of this link can be found in Bryant (2003).

[23] This data is available for the start of each decade, thus we approximate both the 2009 and 2012 shares by the 2010 share.

[24] Whilst the coefficients of both lnGNIpc and $(\text{lnGNIpc})^2$ are individually statistically insignificant in 2000, we can reject the joint hypothesis that both are zero at all conventional significance levels.

with poor access to credit. Similar considerations pertain to the purchase of other major assets, including cars.

Given that Credit is the only significant variable over and above the simple model, (and given that some variables are correlated, such as income per person and the generosity of the welfare state), columns 7-9 extend the simple model with the inclusion of Credit only. The coefficients on log GNIpc and its squared term are similar to those of the simple model. However, we find that the institutions supporting credit were positively and significantly associated with household durables in 2000 and at the onset of the GFC in 2009.[25]

The evidence that MWI incorporates the ability (or otherwise) to practice life-cycle smoothing, as shown by the relationship with credit rights in 2000 and 2009, makes clear the importance of the wealth component within our MWI measure. This is a key result. Economists' models of household behaviour over time incorporate the recognition that credit is important to enable individuals to smooth consumption given the nature of income over the life-cycle. A measure of material wellbeing should reflect this desire, and, unlike traditional income measures of material wellbeing, our measure does so.

6.3. Convergence

In determining the validity of a new material wellbeing measure one should consider its consistency with conventional macroeconomic 'stylised' facts. The columns of Table 4 hinted at a degree of convergence in household durables; economies which enjoyed the strongest MWI growth over the entire period (Russia, Chile, Latvia, Poland and Thailand) had some of the lowest MWI levels in 2000. This absolute convergence is consistent with the standard neoclassical growth model (Solow, 1956).

The relationship is seen more clearly in Figure 5, which plots the annualised change in lnMWI against its lagged level, by period. We observe a strong negative relationship between initial levels of MWI and its subsequent growth, with the strength of the relationship increasing in lag length. We consider this relationship further by estimating the following beta-Convergence equation consistent with Sala-i-Martin (1996), augmented to allow for varying lag lengths:

$$\ln MWI_{it} - \ln MWI_{i,t-s} = \alpha + s\beta \ln MWI_{i,t-s} + \Gamma X_{it} + \upsilon_{it} \quad (11)$$

[25] The fading relationship between lnMWI and Credit over time, as implied by reductions in both the magnitude of point estimates and their significance, is consistent with the improvement of credit institutions that is observed over the period. Thus, it may be that credit has become less of a binding constraint for many households in our sample.

where i and t are country and year indices respectively, and s denotes lag length. This specification allows for additional regressors, X, such as national income and inequality, to control for cross-country heterogeneity.

Table 8 displays the results from estimating the above equation, separately for the 2000-2009, 2009-2012 and full 2000-2012 periods. Consider first the simple relationship exhibited in Figure 5, detailed in columns (1), (4) and (7). The negative sign of the parameters implies convergence, and the magnitude of the estimates from the two longer periods are similar to those found in the literature on economic convergence (Sala-i-Martin, 1996). We estimate an annual speed of beta-convergence of 3% for the period 2000-2009. That is, a 10% reduction of MWI today is associated with subsequent annual MWI growth that is of 0.3 percentage points higher. In the latter period we find a quicker speed of convergence (3.99%), with the speed of convergence over the whole period (3.06%) closer to that of column (1).

We analyse whether this relationship holds in the presence of additional regressors. For the early period, column (2) shows no significant relationship between MWI changes and previous levels when national income is included in both lagged levels and contemporaneous changes, with the explanatory power coming through the relationship between changes in lnMWI and changes in lnGNIpc as seen in Figure 4. This effect is preserved when the inequality terms are included (column (3)), whilst we observe a strong association between changes in MWI and changes in AIM, suggesting that growth in the mean level of resources is inversely related to the growth in inequality. This may be for two reasons. The first is that an increase in inequality due to a rise in high incomes leads to a decreasing rate of increase in MWI (as shown by the coefficient of $GNIpc^2$ in Table 7) thus greater inequality reduces the rate of MWI convergence. The second reason is that greater inequality may indeed reduce economic growth (Cingano, 2014); however our inclusion of controls for the level and change in GNIpc means that the former explanation is the more relevant here.

The statistical significance of convergence terms is preserved in the presence of GNIpc terms for 2009 (column (5)), as well as across all models considered for 2000-2012. Further, changes to national income remains a strong predictor of the change in lnMWI in both 2009-2012 and 2000-2012, as do changes in AIM over the longer period. Overall, the analysis provides strong evidence of convergence in international possession rates, as predicted by economic theory, further supporting the material wellbeing interpretation of the MWI metric.

6.4. Distributional Estimates

The material wellbeing framework presented in this paper draws on household-level data, which enables analysis of within-country distributions; we now consider the validity of our preferred distributional measure through its relationship to a conventional alternative.

Figure 6 plots the relationship between our AIM(1) and the Gini coefficient of household incomes, where the latter is estimated for each country by the OECD and the World Bank.[26] We find a strong positive relationship between the two aggregate measures, implying that countries which have higher levels of income inequality also tend to have higher levels of inequality in household durables; an observation which supports the distributional inference of our material wellbeing framework. Importantly, however, there exists considerable variation around this simple relationship, with a wide distribution of possession inequality values observed across countries with relatively low levels of income inequality. This suggests that rather than replicating existing estimates, our measure captures important additional distributional information.

7. Applications

We now consider two applications of the MWI to illustrate the usefulness of the measure. First, we compare the strength of MWI and GNIpc in predicting alternative wellbeing measures. Second, we use the household-level data to consider the evolution of the 'global' MWI distribution between 2000 and 2012, where the 'global' distribution comprises the 40 economies in our balanced panel.

7.1. Predictive Power of MWI vs GNIpc

Having established the broad, but not one-to-one link between MWI and national income, we consider their relative powers as a predictor of wider wellbeing. To do so, we contrast 2012 GNIpc and MWI values with 3 measures of cross-country wellbeing from the OECD's 2012 Better Life index: life expectancy, mean life satisfaction and mean self-reported health.[27]

[26] There is a considerable number of missing observations in the Gini coefficient of income data. Missing observations are linearly interpolated, which provides a reasonable approximation in levels, however this approach likely produces substantial measurement error in the inter-period changes, precluding any dynamic analysis.

[27] 9 of the 40 countries in our balanced panel are not featured in the OECD Better Life Index of 2012; specifically Albania, Argentina, Bulgaria, Hong Kong, Indonesia, Latvia, Liechtenstein, Romania and Thailand. We obtained life expectancy estimates for these counties from the World Bank database however this was not possible for life satisfaction or self-reported health – these countries are omitted from that analysis. Similarly, the Better Life

Figure 7 contrasts the well documented Preston Curve relationship (Preston, 1975) between national income per capita and life expectancy with the analogous relationship using MWI in place of GNIpc. The left panel updates the curve to 2012, showing that the relationship between GNIpc and life expectancy remains strong today. However, we find MWI performs almost equally well when Hong Kong (the sole outlier in the relationship between MWI and GNIpc) is excluded - the resulting R-squared between MWI and life expectancy is 0.5865, compared with 0.5812 for that between GNIpc and life expectancy. However the two material welfare metrics differ substantially in their predictive power over other welfare measures. Excluding Hong Kong, we find GNIpc explains more than 33% of the variation in cross-country average life satisfaction scores, whereas MWI explains just 13% of the cross-country variation in average life satisfaction scores (see Figure 8). In contrast, MWI is a much stronger predictor of self-reported health (Figure 9), with MWI explaining 37% of the variation in self-reported health compared with that using GNIpc of 21%. These examples highlight important differences in aspects of wellbeing that are being measured between our metric and GNIpc. Further research is required to examine the mechanisms through which these different aggregate associations are realised, and, if data allow, the same relationships could be explored using unit record data.

7.2. Analysis of the 'World' MW Distribution

The distribution of resources across individuals has become a central topic of recent economic analysis. One such study (Milanovic, 2012), considers the entire global distribution of real income growth for the 20 years to 2008. That analysis shows that the largest relative gains in income over the period were enjoyed by those near the global median. To contribute to this discussion we consider the evolution of the global MW distribution, where the world is taken to comprise the 40 countries within our balanced sample.[28] We note that this sample is heavily skewed towards OECD countries (29/40), thus we are unlikely to replicate growth at the bottom of the true world distribution.[29]

In order to construct a world HMW distribution that reflects both country-specific distributions and global population patterns, we duplicate each PISA observation by the ratio of

Index self-reported health estimates were not reported for Brazil or Russia, and thus they are also omitted from that analysis.

[28] These economies represent 27% of 2010 world population, or 43% of the world population outside of India and China, according to UN (2010). Further, PISA coverage is increasing over time which will enable a greater share of world populations to be covered in future years.

[29] Recall also that our unit of observation is a household with a 15-year old, thus country-specific distributions will not be representative of the wider population for countries where education to age 15 is not compulsory.

that country's population of 10-19 year olds to the corresponding number of PISA respondents (which represents a multiple of our best estimate of the true 15 year-old population).[30] Figure 10 plots the resulting 'world' HMW distribution. Firstly, panel (a) plots the level of HMW at each percentile, by survey year, producing a distribution that exhibits the expected shape: in the year 2000, 22% of the 'world' population had household-equivalised material wellbeing of less than $1000, whilst those in the top 20% enjoyed HMW of more than $4000, and the very richest in our sample enjoyed almost double that amount. Panel (a) also documents a marked increase in HMW since 2000 for much of the global middle class, suggesting a marked reduction in global inequality.

To consider the evolution of the distribution more directly, including the relative winners and losers, panel (b) plots the relative HMW growth rate for each percentile over the periods 2000-2009 and 2009-2012. We find that the global economic expansion most favoured those near the 30th percentile of the world distribution, where annual MWI growth of up to 4% was enjoyed between 2000 and 2009. Growth was decreasing around this percentile such that those at the very top and very bottom enjoyed little growth over this period. This result is consistent with the recent concentration of income growth for the global middle class, as documented in Milanovic (2012). However, the distribution of growth is quite different for the period following the Global Financial Crisis; the biggest winners were those near the 15th percentile, with the vast majority of the benefits enjoyed by those in the bottom 30 percentiles. These results are driven by the strong economic growth experienced by Latin American, Southeast Asian and Eastern European countries over this period, as discussed in Section 6.2. The relatively unexceptional growth enjoyed by those at the top of the distribution in both periods could reflect their proximity to the upper-bound; however the variation in growth rates before and during the global financial crisis suggests that economic factors are also important. Furthermore, the variation in intra-period experiences for low and middle HMW households is suggestive of the power of this metric to provide valuable information on multi-country distributional outcomes.

Panel (c) displays the year-specific Lorenz curves, with percentile on the x-axis and the cumulative share of total MWI on the y-axis. In contrast to the concerns of rising inequality within developed economies, we find that the global inequality in household material wellbeing by this measure fell substantially between 2000 and 2012, as implied by the reduced curvature of the Lorenz curves; the resulting Gini coefficients across percentiles for 2000, 2009 and 2012 were 0.304, 0.274 and 0.254, respectively.

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[30] We use population estimates from 2000 for that year and 2010 estimates for both 2009 and 2012.

8. Sensitivity Analysis

Thus far our attention has been devoted to analysing various aspects of our material wellbeing measure. However our metric is necessarily determined by imperfect data on household possessions as well as by judgements over their appropriate weights. To establish the sensitivity of our methodology to alternative datasets and assumptions (and hence its usefulness as a framework to define material wellbeing in alternative applications) it is important to understand the impact of such limitations. Accordingly, subsection 8.1 explores the impact of varying the possession bundle on our metric, while subsections 8.2 and 8.3 document the sensitivity of our results to alternative weighting schemes.

8.1. Possession Simulations

Ideally, one should analyse how our material wellbeing measure would differ if we had data on a wider set of consumer durables, such as other home appliances. Without such data, we cannot definitively say. However, we can gain information about the types of goods that would have a substantive impact on rankings by creating a set of pseudo-MWI metrics, each of which omits a different PISA survey possession when defining material wellbeing, and then describing how the distribution of MWI and pseudo-MWI ranking differences is related to the characteristics of the omitted possession. The distributions of the difference in rankings, by possession, pooling across all country-year observations, is depicted in Figure 11.[31]

We find that excluding some possessions can have a material effect on rankings, whilst the effect of others is trivial. Specifically, individually excluding dictionaries, desks, educational software, or textbooks from the calculation of material wellbeing does not change the ranking of any country-year observation, and there are only minor changes due to the exclusion of artwork, bedrooms, classic literature, dishwashers, poetry, and study places. In contrast, the exclusion of cars changes rankings by up to 15 places, with an average absolute change of ranking of 3.18 places, whilst bathrooms, cellphones, computers and the internet have a moderate impact on rankings.

Of the five possessions which affect rankings the most, four correspond to multi-response questions.[32] The reduced censoring imposed by the multiple response questions almost ensures

[31] For example, when 'Study Place' is omitted from the definition of HMW, the pseudo-MWI ranking for 92% of country-year observations is equivalent to their MWI ranking, whilst the ranking for 4% of observations is one place higher than that implied by MWI, and one place lower for another 4% of observations.

[32] The other case is the internet.

higher average possession quantities and greater variation both within and across countries than other questions, as observed in Table 2. Unsurprisingly, a possession's impact on rankings is also highly correlated with its weight used in the MWI; of the five possessions which affect rankings the most, four (other than computers) have amongst the five highest annualised prices, whilst the four possessions which have no impact on rankings are among the six possessions with the lowest annualised prices. The third highest annualised price for internet, coupled with relatively high variation in cross-country means, explains the importance of this possession in spite of its binary status. Similarly, the relatively low weighting on computers appears to be offset by the pronounced variation across country means.

The minor impact of excluding the number of bedrooms from MWI is comforting, given that it is a derived variable. We find that 78% of country-year rankings are unaffected by this exclusion, whilst no country-year observation changes rank by more than 2 places. This suggests that the analysis of Sections 6 and 7 would be extremely similar had we used the simple alternative of including the 'own room' indicator in MWI.

In light of these sensitivity tests, we conclude that the results from using a wider basket of possessions will be influenced most by the inclusion of possessions that enjoy high rents, low levels of censorship and high degrees of variation across countries.

8.2. Weighting Shock Simulations

Economic theory states that, at the margin, a good's price reflects its benefit; unfortunately, however, we observe the possessions of numerous households, not the marginal transaction. As such, household utility will differ from that implied by market-clearing prices for all goods. The resulting uncertainty regarding the appropriate weights to use in the representative utility function leads us to examine the ordinal sensitivity of our metric with respect to weights. Specifically, we augment the weight on each possession by introducing a random multiplicative term. For each good we take an independent random draw from the symmetric triangular distribution on the interval [0.8, 1.2], construct a pseudo-MWI for each country based on the augmented prices and then compare the consequent rankings with those associated with our central measure, evaluating the deviations from 1000 repetitions - thus we consider how our results would change if prices were correct on average, but could deviate by as much as 20% in either direction.[33] Note that the

[33] We adopt the symmetric triangular distribution because (i) the probability of an observation is decreasing in its distance from the mean, (our best estimate of the appropriate weight), and (ii) the domain of the probability distribution function is bounded, as prices cannot be negative or infinitely positive.

weighting shock is country-invariant, following the discussion of country-invariant prices in Section 4, but is independent across goods.

Figure 12 displays the distribution of ranking deviations, pooling over all country-year observations as well as repetitions. We find that there is no difference between the augmented-price MWI rankings and our central MWI rankings in more than 75% of simulations, with no deviations in rankings greater than 4 (in absolute value) observed, whilst 95% of cases have a deviation no greater than 1 in absolute value. This relative insensitivity to moderate changes in the weighting scheme provides support at least for the ordinal interpretation of our framework. It is the case, however, that the variation in rankings is increasing in the range of the interval from which we draw our shocks, thus wider price shock intervals will produce different results.

8.3. Weighting by Observed Expenditure Shares

Given that we have data on only a small set of household possessions, which are then weighted by their annualised prices to define HMW, the relative HMW weight for observed possessions is considerably greater than that associated with the entire set of household resources. For example, cars and housing attributes are responsible for 31.77% and 38.62% of HMW flows at the mean, respectively, whereas these categories represent just 11.6% and 22.3% of annual Australian expenditure, respectively. In this scenario we examine how our results would change if we used a weighting scheme that is consistent with these aggregate expenditure shares.[34] Figures 13, 14, and 15 document the deviations between a country's MWI, AIM(1) and IMWI(1) ranking with those under the Australian expenditure weighted scheme, by year, whilst the relative values can be found in Table 9. [35]

Figure 13 shows that expenditure weighting has little impact on MWI rankings for the poorest half of countries, while the Scandinavian countries jump ahead of the Anglo-Saxon settler countries in the top half. Overall, we find that rankings between weighting systems do not differ by more than 3 places for two-thirds of our country-year observations. Inequality rankings (Figure 14) appear even less sensitive to the alternative weighting schemes with only minor variation in rankings in the middle of the distribution. Accordingly, the variation in IMWI rankings (Figure

[34] Note that these are shares of total expenditure; the share of expenditure on durables, which is a measure more consistent with our framework, is likely to be greater. This scenario, therefore, represents a relatively drastic reweighting scheme. Computationally, to achieve the desired weights, we reduce the weight on cars and all housing components by 42.26% and 63.49% respectively, whilst increasing all other weights by a factor of 2.23.

[35] We intended to contrast the impact of weighting by both Australian and Japanese expenditure shares, in the spirit of Dowrick and Quiggin (1993), however we could not obtain expenditure shares for cars in Japan, whilst using the share of Japanese expenditure on transport largely duplicated the Australian results.

15), perfectly replicate those of Figure 13 as the documented cardinal changes in inequality are relatively minor.

This analysis suggests the broad cross-country material wellbeing patterns analysed earlier are robust to a considerably different weighting scheme, one which arises from a substantially different motivation, and are therefore not the result of an overdependence on one or two specific durables categories. Thus, while Subsection 8.1 showed that the exclusion of cars could materially change country rankings, the use of the substantially lower expenditure weights does not result in major ranking changes across our three measures.

9. Conclusions

As is now well-recognised, national income per capita is an imperfect measure of material welfare. This paper progresses the literature on the measurement of material wellbeing by developing a framework for measuring household material wellbeing that satisfies the key recommendations of SSF for constructing a material wellbeing metric – specifically, focusing on income and consumption rather than production, and emphasising the household perspective - within a capabilities framework consistent with Sen (1985). Both distributions and means of material wellbeing are highlighted (although the paper does not address other components of overall wellbeing, such as social and environmental wellbeing).

Our metric accounts for the annual flow of consumption services from a set of consumer durables within the home, which theoretically approximates the welfare associated with these possessions at the margin. This framework differs from alternative welfare metrics which are based on household resources by using market prices to weight the item, thereby constructing an absolute proxy for material welfare, rather than a data-driven approach akin to principal components analysis.

To consider the usefulness of this framework, as well as to understand the implications of several assumptions, we apply our methodology to a multi-level repeated cross-sectional dataset, drawn from the OECD's PISA surveys, incorporating the responses of households from 40 countries at three points in time. We define a household's material wellbeing (HMW) as the annual rental value corresponding to a given set of household durables. We then map HMW into three series: the Material Wellbeing Index (MWI) represents the country-year mean of HMW; the Atkinson's Inequality Measure (AIM) captures the degree of inequality in the country-year-specific HMW distribution; and the Inequality-adjusted MWI (IMWI), which simultaneously reflects the level and distribution of resources. To extend the framework to other applications we note that the precision of material wellbeing estimates is increasing in the number of possessions which have high annual rental prices, have multiple units in the home, and in the case of cross country analysis, have high degrees of variation in ownership rates across countries.

While it is difficult to validate any new metric there is evidence that our measure is capturing important aspects of material wellbeing. Firstly, micro-level analysis shows our measure of household material wellbeing is positively associated with household income - a more established measure of material wellbeing. Secondly, we find a strong positive nonlinear relationship between our aggregate measure and Gross National Product per capita (GNIpc), demonstrating that the household-level correlation is preserved under aggregation. Further, we find that this relationship also holds in changes, establishing a link between the series. Furthermore, our favoured measure of dispersion produces country-year rankings consistent with conventional measures of household income inequality.

Evaluated collectively, the above evidence suggests that our material wellbeing measure is capable of reproducing observed material wellbeing orderings. However, the usefulness of a new metric requires it does not simply replicate other metrics; rather one requires the presence of additional information. Importantly, we find credit institutions play a key role in transforming (per capita) income into MWI - a result that follows from focusing on durables consumption. This is a key insight contributed by our new metric. Life-cycle analysis suggests that material wellbeing should not be determined exclusively by today's income, but also by wealth and by expectations of future income flows. The ability of this measure to simultaneously capture income and consumption smoothing behaviour reflects a significant advancement in the measurement of material wellbeing.

Other macro-level results indicate that the MWI is a stronger predictor of average health scores than income per capita, whereas the reverse is true for life satisfaction. This suggests that further research is required in order to understand how the various components of material wellbeing (income, wealth and consumption) are linked with alternative measures of non-material wellbeing.

Use of the micro-level data casts new insights into developments of income distributions within and across countries. Consistent with Milanovic (2012) we find that in our (40 country) 'world', material possessions became more evenly distributed over the twelve years to 2012, and this was reflected also in reductions for most countries in intra-country inequality. Cross-country convergence is also observed in material wellbeing for our 40 countries, consistent with declining global inequality.

Despite a strong positive relationship between MWI and national income per capita, certain countries stand out as having a higher material wellbeing rank than their corresponding income rank. In particular, in 2012, the four Anglo-Saxon settler countries (USA, CAN, NZL, AUS) are calculated to the highest levels of MWI, whereas only one of these countries (USA) is ranked in the top four by income (and even then only fourth). Our analysis suggests that access to credit may help explain this pattern. In doing so, our analysis shows that research into when and why micro-level and macro-level deviations between income and durables consumption (which is at the core of our measure) occur is a priority for understanding which factors can lift the material wellbeing of individuals and nations aside from increasing income.

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Appendix 1: Approximating Utility from Rental Expenditure

To see the relationship between rental expenditure and utility first consider the consumer optimisation problem corresponding to an infinite period model with two durable goods, A and B, and a composite non-durable good, C. Suppose the consumer derives utility from both non-durables consumption and the flow of consumption services from durable goods, $U(\theta_A x_{At}, \theta_B x_{Bt}, x_{Ct})$, where x_{jt} is the stock of good j held in period t and θ_j is the constant ratio of consumption services to stock for durable good j. Further suppose the individual begins each period with nominal wealth w_t and earns nominal income y_t, the sum of which can be allocated across consumption of nondurables, durables or financial assets, f_t.[36]

$$w_t + y_t = P_{At}x_{At} + P_{Bt}x_{Bt} + P_{Ct}x_{Ct} + f_t \qquad (A1)$$

Now let the return on durables be the expected real rate of capital gain, $\dot{P_{jt}}$ less the rate of depreciation, δ_j. With substitution of A1, the intertemporal wealth constraint is then as follows:

$$\begin{aligned} w_{t+1} &= (1+r_t)f_t + \left(1+\dot{P_{At}}-\delta_A\right)P_{At}x_{At} + \left(1+\dot{P_{Bt}}-\delta_B\right)P_{Bt}x_{Bt} \\ &= (1+r_t)(w_t + y_t - P_{Ct}x_{Ct}) + \left(\dot{P_{At}}-r_t-\delta_A\right)P_{At}x_{At} + \left(\dot{P_{Bt}}-r_t-\delta_B\right)P_{Bt}x_{l} \end{aligned} \qquad (A2)$$

Due to the recursivity of this problem we can write the consumers problem as follows:

$$V_t = \max_{x_{At}, x_{Bt}, x_{Ct}} \{U(\theta_A x_{At}, \theta_B x_{Bt}, x_{Ct}) + \rho V_{t+1}(w_{t+1})\} \qquad (A3)$$

The optimal solution requires substituting (A2) into (A3), and then differentiating with respect to the 3 choice variables, $x_{jt}, \forall\, j \in \{A, B, C\}$. This yields the following first order conditions:

$$\frac{\partial U}{\partial x_{At}} = \frac{\partial U}{\partial(\theta_A x_{At})}\frac{\partial(\theta_A x_{At})}{\partial x_{At}} = \rho V_{t+1}{}'(w_{t+1})\left(r_t + \delta_A - \dot{P_{At}}\right)P_{At}$$

$$\frac{\partial U}{\partial x_{Bt}} = \frac{\partial U}{\partial(\theta_B x_{Bt})}\frac{\partial(\theta_B x_{Bt})}{\partial x_{Bt}} = \rho V_{t+1}{}'(w_{t+1})\left(r_t + \delta_B - \dot{P_{Bt}}\right)P_{Bt}$$

$$\frac{\partial U}{\partial x_{Ct}} = \rho V_{t+1}{}'(w_{t+1})(1+r_t)P_{ct}$$

[36] Instead of a borrowing constraint we impose a no-Ponzi scheme condition on borrowing, stating that in the limit assets must be positive: $E_t \lim_{s\to\infty}\left[\prod_{s=0}^{\infty}\left(\frac{1}{1+r_{t+s}}\right)\right] f_{t+s} \geq 0,$

The above equations show that the individual should allocate expenditure such that the benefit of an extra unit of any good, relative to its net costs, is equal to the shadow price (the present value of holding an additional dollar in the next period, which we denote as λ). That is

$$\frac{\theta_A . \partial U/\partial(\theta_A x_{At})}{(r_t+\delta_A-\dot{P_{At}})P_{At}} = \frac{\theta_B . \partial U/\partial(\theta_B x_{Bt})}{(r_t+\delta_B-\dot{P_{Bt}})P_{Bt}} = \frac{\partial U/\partial x_{Ct}}{(1+r_t)P_{Ct}} = \lambda = \rho V_{t+1}{}'(w_{t+1}) \qquad (A4)$$

Now suppose we observe an individual's stock of nondurables at levels x_{At} and x_{Bt}, but do not observe their level of consumption of nondurables, x_{Ct}, or the seperable utility function, $U(\theta_A x_{At}, \theta_B x_{Bt}, x_{Ct})$. Can we make any comment on welfare/wellbeing? Consider the first-order Taylor series approximation of the utility function U at the point $(0,0,x_{Ct})$, i.e. where consumption of nondurables is possibly nonzero but the stock of durables is zero, about the partially observed point $(\theta_A x_{At}, \theta_B x_{Bt}, x_{Ct})$.

$$U(0,0,x_{Ct}) \approx U(\theta_A x_{At}, \theta_B x_{Bt}, x_{Ct}) + \frac{\partial U}{\partial \theta_A x_{At}}(0-\theta_A x_{At}) + \frac{\partial U}{\partial \theta_B x_{Bt}}(0-\theta_B x_{Bt}) + \frac{\partial U}{\partial x_{ct}}(x_{Ct}-x_{Ct})$$

The above expression can be rearranged, with substitution from equation A3, as follows

$$U(\theta_A x_{At}, \theta_B x_{Bt}, x_{Ct}) - U(0,0,x_{Ct}) \approx \frac{\partial U}{\partial \theta_A x_{At}}\theta_A x_{At} + \frac{\partial U}{\partial \theta_B x_{Bt}}\theta_B x_{Bt}$$

$$= \left(\frac{\partial U}{\partial(\theta_B x_{Bt})}\frac{\theta_B(r_t+\delta_A-\dot{P_{At}})P_{At}}{\theta_A(r_t+\delta_B-\dot{P_{Bt}})P_{Bt}}\right)\theta_A x_{At} + \frac{\partial U}{\partial \theta_B x_{Bt}}\theta_B x_{Bt}$$

$$= \left((r_t+\delta_A-\dot{P_{At}})P_{At}x_{At} + \left((r_t+\delta_B-\dot{P_{Bt}})\right)P_{Bt}x_{Bt}\right)\frac{\theta_B . \partial U/\partial(\theta_B x_{Bt})}{(r_t+\delta_B-\dot{P_{Bt}})P_{Bt}}$$

$$= \left((r_t+\delta_A-\dot{P_{At}})P_{At}x_{At} + \left((r_t+\delta_B-\dot{P_{Bt}})\right)P_{Bt}x_{Bt}\right)\lambda$$

From which the main result follows: the sum of the annual rental cost of durables approximates the increased utility over the zero-durables bundle, holding non-durables constant and expressed in monetary terms.

$$R_{At}x_{At} + R_{Bt}x_{Bt} = (r_t+\delta_A-\dot{P_{At}})P_{At}x_{At} + \left((r_t+\delta_B-\dot{P_{Bt}})\right)P_{Bt}x_{Bt}$$
$$= \frac{U(x_{ct}, \theta_A x_{At}, \theta_B x_{Bt}) - U(x_{ct}, 0,0)}{\lambda} \qquad (A5)$$

Appendix 2: Equivalisation Errors with Under-observation

The two most prominent approaches to equivalised household flows are (i) the square root method, which divides flows by the square root of household size, and (ii) the OECD methods, which divide flows by the sum of household size-invariant weights (with a minimum weight of 0.3 for a child aged under 14 years of age).

<u>Theorem</u>: The difference between the true equivalisation factor by which material wellbeing flows should be divided and the factor employed in the presence of under-observed household size, is lower under the square root method than under the prominent alternative methods for households with observed size of at least 3.[37]

<u>Proof:</u> Consider a household of size N, but suppose we do not observe x members of the household. That is, we observe an underestimate of true household size: $\underline{N} = N - x$. What implication does this under-observation have on the equivalisation factor? We define the error per unobserved individual under the square root method as follows:

$$\upsilon_{\underline{N},x} = \begin{cases} 0, \text{if } x = 0 \\ \frac{1}{x}\left(\sqrt{N} - \sqrt{\underline{N}}\right) \end{cases}$$

For example, square root equivalisation of a household of size 5 requires that the wellbeing flows are divided by the square root of 5. Suppose, however, we observe only 3 members of this household. In that case, the error per unobserved member is equal to
$\upsilon_{5,2} = \frac{1}{2}\left(\sqrt{5} - \sqrt{3}\right) \approx 0.252$. We can bound the under-observation error as follows:

$$\upsilon_{\underline{N},x} = \frac{1}{x}\left(\sqrt{N} - \sqrt{\underline{N}}\right) = \frac{\sqrt{N} - \sqrt{\underline{N}}}{N - \underline{N}} = \frac{\sqrt{N} - \sqrt{\underline{N}}}{\left(\sqrt{N} - \sqrt{\underline{N}}\right)\left(\sqrt{N} + \sqrt{\underline{N}}\right)} = \frac{1}{\sqrt{N} + \sqrt{\underline{N}}} \leq \frac{1}{2\sqrt{\underline{N}}}$$

This error per unobserved individual is strictly decreasing in $\underline{N}$, thus $\upsilon_{\underline{N},x}$ will be less than the minimum OECD weight of 0.3 for sufficiently large $\underline{N}$. Specifically,

$$\upsilon_{N,x} \leq 0.3 \text{ when } \frac{1}{2\sqrt{\underline{N}}} \leq 0.3, \text{ or } \underline{N} \geq \left(\frac{1}{2 \times 0.3}\right)^2 = \frac{100}{36} = \frac{25}{9}$$

With rounding, we find that, in the presence of under-observation, all households with an observed household size of at least 3 will have an equivalisation factor closer to the true and intended value under the square root method than under the alternative OECD methods.

[37] This analysis does not consider which method is preferred under perfect observation.

Appendix 3: Data Series Sources

A3.1 Expenditure Weights

The reweighting simulation of Section 8.3 draws upon the 16th Series Expenditure Weights, as used to aggregate price changes by the Australian Bureau of Statistics. The values are available at http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/6470.0Main+Features142011.

A3.2 Gini Index of Household Incomes

This derived variable combines two sources so most of our balanced panel of countries have data in 2000, 2009 and 2012. Firstly, we use World Bank estimates (available from http://data.worldbank.org/indicator/SI.POV.GINI), which includes few developed countries, and OECD estimates (available from http://stats.oecd.org/Index.aspx?DataSetCode=IDD#). 22 countries appear in both datasets and their values are extremely similar across the sources, giving confidence that the sources can be merged. To obtain one country-year value for these observations we use the simple average between sources.

However within each dataset there is a considerable amount of missing data. To reasonably infer the level of inequality at a point in time we linearly interpolate observations according to the following process: if the observation is non-missing for the required year we retain that value; if the required observation is missing, however there exists an observation in the either preceding or succeeding year we accept that value, applying the average if both are non-missing; if the observations in the required year, as well as the preceding and succeeding years, are missing, as well as observations but there exists an observation either two years before or two years after the required year we accept that value, again applying the average if both values are non-missing; finally, if there are no observations with two years of the required observations we set the leave the value as missing.

A3.3 Gross National Product per Capita (GNIpc)

The measure of National Income per Capita we consider in this study is the PPP-adjusted GNIpc, and expressed in 2011 international dollars, as obtained from http://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD on 1 May, 2015.

A3.4 Proportion of the Population of Working-age (Demog)

We derive a demographic variable to reflect the proportion of the population of working-age, using data obtained from the Trends in International Migrant Stock: Migrants by Age and Sex report by the United Nations in 2011. This yields population data for all required countries as at 2000 and 2010, across 5-year age bins, from which we compute the proportion the total population older than 19 but younger than 65. Given data is available only for the start of each decade we use the 2010 proportion for both 2009 and 2012 analysis.

A3.5 PISA sources

The major data source of this study is the Programme for International Student Assessment. We draw upon the 2000-2012 Student Questionnaire data files, and the 2000-2012 Parental Questionnaire data files. All data can be obtained from http://www.oecd.org/pisa/pisaproducts/

A3.6 Price Data

As described in the footnotes of Table 3.

A3.7 Social Expenditure per Person (Transpc)

Social expenditure can break the link between income and (non-durables) consumption. For example, unemployment insurance allows one to consume whilst income is zero, but it therefore also reduces the need to save for a rainy day. To capture this dimension we construct the series of government subsidies and transfers per capita, which is formed by multiplying three data series: GNIpc (described above); government expenses as a percentage of GDP (available http://data.worldbank.org/indicator/GC.XPN.TOTL.GD.ZS); and subsidies and transfers as a percent of expenses (http://data.worldbank.org/indicator/GC.XPN.TRFT.ZS).

A3.8 Strength of Legal Rights Index (Credit)

To capture the institutional factors which encourage or discourage lending in a country we use the Strength of Legal Rights Index - an index constructed by the Doing Business Project of the World Bank. We obtained the series from http://data.worldbank.org/indicator/IC.LGL.CRED.XQ/countries on 2 December, 2014.

Table 1: PISA Responding Student Counts, By Country and Year

		Number of Student Respondents				
ISO Code	Country/Economy Name	2000	2003	2006	2009	2012
ALB	Albania	2783			4596	4743
ARE	United Arab Emirates					11500
ARG	Argentina	2230		4339	4774	5908
AUS	Australia	2859	12551	14170	14251	14481
AUT	Austria	2640	4597	4927	6590	4755
AZE	Azerbaijan			5184	4691	
BEL	Belgium	3784	8796	8857	8501	8597
BGR	Bulgaria	2615		4498	4507	5282
BRA	Brazil	2717	4452	9295	20127	19204
CAN	Canada	16489	27953	22646	23207	21544
CHE	Switzerland	3396	8420	12192	11812	11229
CHL	Chile	2721		5233	5669	6856
COL	Colombia			4478	7921	9073
CRI	Costa Rica					4602
CZE	Czech Republic	3066	6320	5932	6064	5327
DEU	Germany	2830	4660	4891	4979	5001
DNK	Denmark	2382	4218	4532	5924	7481
ESP	Spain	3428	10791	19604	25887	25313
EST	Estonia			4865	4727	4779
FIN	Finland	2703	5796	4714	5810	8829
FRA	France	2597	4300	4716	4298	4613
GBR	United Kingdom	5195	9535	13152	12179	12659
GRC	Greece	2605	4627	4873	4969	5125
HKG	Hong Kong-China	2438	4478	4645	4837	4670
HRV	Croatia			5213	4994	5008
HUN	Hungary	2799	4765	4490	4605	4810
IDN	Indonesia	4089	10761	10647	5136	5622
IRL	Ireland	2128	3880	4585	3937	5016
ISL	Iceland	1882	3350	3789	3646	3508
ISR	Israel	2483		4584	5761	5055
ITA	Italy	2765	11639	21773	30905	31073
JOR	Jordan			6509	6486	7038
JPN	Japan	2924	4707	5952	6088	6351
KAZ	Kazakhstan				5412	5808
KGZ	Kyrgyzstan			5904	4986	
KOR	Korea	2769	5444	5176	4989	5033
LIE	Liechtenstein	175	332	339	329	293
LTU	Lithuania			4744	4528	4618
LUX	Luxembourg	1959	3923	4567	4622	5258
LVA	Latvia	2149	4627	4719	4502	4306
MAC	Macao-China		1250	4760	5952	5335
MEX	Mexico	2567	29983	30971	38250	33806
MKD	Macedonia	2544				
MNE	Montenegro			4455	4825	4744
MYS	Malaysia					5197
NLD	Netherlands	1382	3992	4871	4760	4460
NOR	Norway	2307	4064	4692	4660	4686
NZL	New Zealand	2048	4511	4823	4643	4291
PAN	Panama				3969	
PER	Peru	2460			5985	6035
POL	Poland	1976	4383	5547	4917	4607
PRT	Portugal	2545	4608	5109	6298	5722
QAR	Dubai (UAE)				5620	
QAT	Qatar			6265	9078	10966
QCN	Shanghai-China				5115	5177
QRS	Perm (Russian Federation)					1761
QUA	Florida (USA)					1896
QUB	Connecticut (USA)					1697
QUC	Massachusetts (USA)					1723
ROU	Romania	2682		5118	4776	5074

(Continued)

Table 1: PISA Responding Student Counts, by Country and Year (continued)

ISO Code	Country/Economy Name	Number of Student Respondents 2000	2003	2006	2009	2012
RUS	Russia	3719	5974	5799	5308	5231
SGP	Singapore				5283	5546
SRB	Serbia			4798	5523	4684
SVK	Slovak		7346	4731	4555	4678
SVN	Slovenia			6595	6155	5911
SWE	Sweden	2464	4624	4443	4567	4736
TAP	Chinese Taipei			8815	5831	6046
THA	Thailand	2959	5236	6192	6225	6606
TTO	Trinidad and Tobago				4778	
TUN	Tunisia		4721	4640	4955	4407
TUR	Turkey		4855	4942	4996	4848
URY	Uruguay		5835	4839	5957	5315
USA	United States of America	2135	5456	5611	5233	4978
VNM	Viet Nam					4959
YUG	Serbia and Montenegro		4405			

ISO Code details the 3 letter country codes used to identify economies in PISA and in our subsequent analysis. The analytical sample focused on in this paper comprises countries which were asked all possession questions in years 2000, 2009 and 2012 - their ISO codes are written in bold for ease of identification. Note, due to incomplete possession questionnaires, this excludes Israel (which is missing data for `own room' and the number of bathrooms in 2012) and Peru (dishwashers in 2000).

Table 2: PISA Possession Data Summary Statistics

	Question Type	Percentage of Responses Missing (%)	Mean Possessions per Student	Across-Country Variation in Means	Mean of Within-Country Variation
Artwork	Binary	3.199	0.585	0.139	0.472
Classic Lit	Binary	3.423	0.537	0.166	0.469
Desk	Binary	2.271	0.895	0.100	0.268
Dictionary	Binary	2.083	0.944	0.055	0.206
Dishwasher	Binary	2.946	0.530	0.279	0.405
Educ. Software	Binary	3.912	0.518	0.169	0.469
Internet	Binary	2.438	0.709	0.290	0.321
Own Room	Binary	2.035	0.798	0.132	0.365
Poetry	Binary	3.123	0.559	0.155	0.470
Study Place	Binary	2.422	0.880	0.075	0.307
Textbooks	Binary	2.513	0.860	0.084	0.327
Bathrooms	Multiple	2.101	1.373	0.375	0.683
Cars	Multiple	2.564	1.306	0.549	0.792
Computers	Multiple	2.442	1.471	0.672	0.772
(Cell) Phones	Multiple	1.724	2.441	0.665	0.633
TVs	Multiple	1.704	2.137	0.370	0.725

Column 1 details whether the corresponding possession was asked as a binary or multiple response question in the PISA survey. Column 2 presents the percentage of responses with a missing value for a given possession. Column 3 presents the average self-reported number of possessions within a household, across all countries and time periods. Column 4 presents the standard deviation of country-year specific possession quantity means, i.e. the across-country standard deviation in means, whilst column 5 details the mean of country-year specific possession quantity standard deviations, i.e. the mean of within-country standard deviations.

Table 3: Data Sources, Prices, Lifespans and Annual Rental Flows

	Price Data Source	Price (USD)	Useful Life (Years)	Annual Rent
Artwork	Amazon.com	2,550	13.3	191.73
Classic Lit	Amazon.com	30	2.0	15.00
Desk	Amazon.com	400	15.5	25.81
Dictionary	Amazon.com	31	2.0	15.34
Dishwasher	Amazon.com	700	6.7	105.11
Educ Software	Amazon.com	30	4.0	7.50
Internet	CES PUMD	700	1.0	700.00
Own Room	Sirmans et al (2006), FRED	20,945	50.0	418.90
Poetry	Amazon.com	30	2.0	15.00
Study Place	Sirmans et al (2006), FRED	10,473	50.0	209.45
Textbooks	Amazon.com	30	2.0	15.00
Bathroom	Sirmans et al (2006), FRED	19,033	25.0	761.31
Cars	Cars.com	6,315	4.0	1,578.75
Computer	NPD Group	671	4.0	167.75
(Cell) Phone	J.D. Power and Associates	852	3.0	284.00
TV	Amazon.com	580	5.0	116.00

Estimated median prices for artwork, desks, dictionaries, dishwashers, educational software and televisions and all books were obtained from Amazon.com.

Given internet charges are already rental payments, we consider the average household expenditure per year directly from 2012 Consumer Expenditure Survey public-use microdata (CES PUMD), obtained from http://www.bls.gov/cex/pumdhome.htm.

The car price reported is the annualised estimated 4 year depreciation on a brand new Toyota Corolla, which uses median price by year data from http://www.cars.com/toyota/corolla/ and predicts the decline in resale value by age.

The value of housing characteristics (bathrooms, bedrooms) is informed by the meta-analysis of Sirmans et al (2006) and the 2014Q1 median US house price obtained from the Federal Reserve Economic Data (FRED). Specifically, we use the average parameter value from hedonic regressions which do not control for size, as we seek the total benefit of a bedroom or bathroom. The value of a study place we assume is one half the value of a bedroom.

Lifespan is defined by the New Zealand Inland Revenue (IR265) as the estimated useful life (years) for depreciation purposes.

To infer the price of a computer we use the average sales price of a Windows computers in the United States during a period of 2013, as reported by NPD Group on https://www.npd.com/wps/portal/npd/us/news/press-releases/windows-touch-and-chromebooks-boost-us-back-to-school-computer-sales-but-not-enough-to-stop-overall-declines-according-to-the-npd-group/ . This is likely to be conservative as it excludes more expensive Apple products and prices were observed during the competitive back to school period.

The annual price of a cell phone is informed by the average individual's cell phone bill of $71 monthly, as reported by J.D. Power and Associates in 2011 (see http://business.time.com/2012/10/18/47-a-month-why-youre-probably-paying-double-the-average-cell-phone-bill/).

Table 4: MWI Values and Rankings, by Year and Levels/Changes

	2000 Levels		2009 Levels		2012 Levels		00-09 Annual %Δ		09-12 Annual %Δ		00-12 Annual %Δ	
	MWI	Rank	MWI	Rank	MWI	Rank	MWI	Rank	MWI	Rank	MWI	Rank
ALB	1891	38	2600	37	2766	38	4.65	5	2.08	8	3.87	6
ARG	2381	30	2791	35	2903	36	2.29	21	1.33	13	2	19
AUS	4194	2	4827	4	4864	4	1.57	34	0.25	28	1.24	34
AUT	3688	11	4335	14	4383	11	1.81	29	0.36	23	1.45	29
BEL	3283	22	4161	19	4214	20	2.67	15	0.42	21	2.1	16
BGR	2498	28	3583	27	3709	27	5.28	2	1.16	14	4.03	4
BRA	2081	37	2570	38	2905	35	2.37	20	4.17	4	2.82	11
CAN	4168	3	4864	3	4911	2	1.73	30	0.32	25	1.38	31
CHE	3479	17	4164	18	4257	18	2.02	25	0.74	18	1.7	24
CHL	2230	33	3014	31	3565	29	4.39	6	5.76	2	4.8	2
CZE	2622	26	3800	25	3955	25	4.21	9	1.34	12	3.49	9
DEU	3648	13	4172	17	4300	15	1.5	35	1.01	15	1.38	30
DNK	3613	14	4095	20	4142	22	1.4	37	0.38	22	1.15	36
ESP	3369	19	4049	23	4238	19	2.06	24	1.53	10	1.93	20
FIN	3669	12	4450	11	4364	13	2.17	22	-0.65	37	1.46	28
FRA	3301	21	4186	16	4271	17	2.67	14	0.67	19	2.17	15
GBR	3595	15	4269	15	4380	12	1.93	28	0.85	16	1.66	25
GRC	3008	24	4074	21	4028	23	3.43	12	-0.38	36	2.46	13
HKG	2324	31	2234	39	2659	39	-0.56	40	5.98	1	1.36	32
HUN	2470	29	3577	28	3605	28	4.2	10	0.25	27	3.2	10
IDN	1402	40	1606	40	1741	40	1.95	27	2.73	6	2.19	14
IRL	3358	20	4638	6	4601	7	3.66	11	-0.27	35	2.66	12
ISL	3965	7	4574	8	4342	14	1.6	32	-1.72	40	0.76	40
ITA	3827	9	4448	12	4475	10	1.69	31	0.2	29	1.31	33
JPN	3567	16	3892	24	3915	26	0.97	39	0.19	30	0.78	39
KOR	2768	25	3420	29	3468	30	2.38	19	0.46	20	1.9	21
LIE	3735	10	4526	10	4760	5	2.16	23	1.69	9	2.04	17
LUX	3890	8	4650	5	4659	6	2	26	0.07	31	1.52	27
LVA	2203	34	3406	30	3441	31	4.96	4	0.34	24	3.79	8
MEX	2231	32	2769	36	2791	37	2.43	17	0.26	26	1.88	22
NLD	3269	23	4057	22	4155	21	2.43	18	0.8	17	2.02	18
NOR	4000	5	4613	7	4596	8	1.6	33	-0.13	34	1.16	35
NZL	4034	4	5014	2	4907	3	2.44	16	-0.72	38	1.64	26
POL	2536	27	3711	26	3993	24	4.32	7	2.46	7	3.86	7
PRT	3443	18	4391	13	4281	16	2.74	13	-0.84	39	1.83	23
ROU	2096	36	2976	32	3104	34	5.14	3	1.42	11	4.01	5
RUS	1825	39	2971	33	3233	33	5.57	1	2.85	5	4.88	1
SWE	3976	6	4537	9	4543	9	1.48	36	0.04	32	1.12	37
THA	2188	35	2927	34	3318	32	4.24	8	4.26	3	4.25	3
USA	4588	1	5092	1	5075	1	1.16	38	-0.11	33	0.84	38

Columns (1), (3) and (5) present the MWI value for the relevant country-year, whilst the associated rankings are displayed in the column to the right (note, lower ranking values indicate higher levels of MWI). Columns (7), (9) and (11) display annualised MWI percentage growth rates for each country-period, with the associated rankings displayed in the column to the right (note, lower rankings indicate higher MWI growth rates).

Table 5a: AIM(1) Values and Rankings, by Year and Levels/Changes

	2000 Levels			2009 Levels			2012 Levels			00-09 Annual Δ			09-12 Annual Δ			00-12 Annual Δ		
	AIM	AIM Rank	Gini Rank	AIM	AIM Rank	Gini Rank	AIM	AIM Rank	Gini Rank	dAIM	dAIM Rank	Δ Gini Rank	dAIM	dAIM Rank	Δ Gini Rank	dAIM	dAIM Rank	Δ Gini Rank
ALB	0.071	28	29	0.085	36	36	0.082	36	36	0.002	38	38	-0.001	17	19	0.001	39	39
ARG	0.097	36	36	0.083	35	35	0.068	33	33	-0.002	13	20	-0.005	3	3	-0.003	6	5
AUS	0.047	13	11	0.031	12	10	0.03	13	11	-0.002	16	16	0	26	27	-0.001	19	20
AUT	0.044	9	9	0.033	16	16	0.031	14	14	-0.001	29	28	-0.001	19	21	-0.001	29	29
BEL	0.046	10	12	0.032	14	13	0.03	10	10	-0.002	22	19	-0.001	20	16	-0.001	22	14
BGR	0.066	26	26	0.06	32	32	0.055	32	32	-0.001	32	31	-0.002	10	11	-0.001	28	26
BRA	0.114	39	39	0.11	37	37	0.09	37	37	0	35	35	-0.007	2	2	-0.002	11	13
CAN	0.05	18	16	0.036	20	18	0.034	18	19	-0.001	23	22	-0.001	18	18	-0.001	23	25
CHE	0.049	15	17	0.03	9	9	0.029	7	9	-0.002	12	12	0	25	26	-0.002	14	11
CHL	0.095	34	35	0.071	33	33	0.077	35	35	-0.004	6	7	0.002	40	39	-0.002	13	15
CZE	0.067	27	27	0.037	21	22	0.037	25	25	-0.003	7	6	0	34	34	-0.002	8	8
DEU	0.05	17	18	0.038	22	23	0.032	15	15	-0.001	26	26	-0.002	9	9	-0.001	18	19
DNK	0.04	6	6	0.029	6	4	0.028	4	4	-0.001	28	24	0	29	32	-0.001	31	30
ESP	0.059	25	25	0.046	28	28	0.035	22	22	-0.001	24	23	-0.004	7	4	-0.002	10	10
FIN	0.041	7	7	0.027	4	5	0.03	11	13	-0.002	20	21	0.001	37	37	-0.001	32	32
FRA	0.049	16	14	0.035	17	17	0.033	17	17	-0.002	21	25	-0.001	21	22	-0.001	25	28
GBR	0.053	20	21	0.036	19	21	0.034	21	23	-0.002	15	18	-0.001	22	24	-0.002	16	22
GRC	0.055	23	24	0.042	26	26	0.037	26	26	-0.001	25	29	-0.002	11	10	-0.001	17	23
HKG	0.047	12	10	0.045	27	27	0.036	24	24	0	36	37	-0.003	8	6	-0.001	30	31
HUN	0.084	32	33	0.042	25	24	0.041	27	27	-0.005	2	1	0	30	31	-0.004	2	2
IDN	0.08	30	30	0.121	38	38	0.108	39	39	0.006	40	40	-0.004	6	7	0.003	40	40
IRL	0.054	22	23	0.032	13	14	0.028	5	7	-0.003	9	8	-0.001	14	13	-0.002	9	9
ISL	0.035	1	2	0.025	2	2	0.029	8	8	-0.001	30	27	0.002	39	40	0	37	37
ITA	0.046	11	13	0.031	10	12	0.03	12	12	-0.002	18	15	0	31	23	-0.001	24	17
JPN	0.047	14	15	0.036	18	19	0.033	16	18	-0.001	27	30	-0.001	15	15	-0.001	26	27
KOR	0.043	8	8	0.027	5	3	0.026	3	2	-0.002	17	14	0	27	28	-0.001	20	18
LIE	0.035	3	3	0.026	3	6	0.025	2	3	-0.001	31	32	-0.001	23	17	-0.001	33	33
LUX	0.052	19	19	0.031	11	11	0.035	23	20	-0.002	10	10	0.001	38	38	-0.001	21	24

(Continued)

Table 5a: AIM(1) Values and Rankings, by Year and Levels/Changes (continued)

	2000 Levels			2009 Levels			2012 Levels			00-09 Annual Δ			09-12 Annual Δ			00-12 Annual Δ		
	AIM	AIM Rank	Gini Rank	AIM	AIM Rank	Gini Rank	AIM	AIM Rank	Gini Rank	dAIM	dAIM Rank	Δ Gini Rank	dAIM	dAIM Rank	Δ Gini Rank	dAIM	dAIM Rank	Δ Gini Rank
LVA	0.084	33	32	0.048	29	29	0.045	29	30	-0.004	4	3	-0.001	16	20	-0.003	3	3
MEX	0.138	40	40	0.142	40	40	0.129	40	40	0	37	36	-0.004	4	8	-0.001	34	34
NLD	0.036	4	4	0.022	1	1	0.021	1	1	-0.002	19	13	0	33	33	-0.001	27	21
NOR	0.035	2	1	0.03	7	8	0.029	9	5	-0.001	34	34	0	32	25	0	36	36
NZL	0.053	21	20	0.033	15	15	0.034	20	21	-0.002	11	11	0	36	36	-0.002	15	16
POL	0.096	35	34	0.052	30	30	0.047	31	31	-0.005	1	2	-0.002	12	12	-0.004	1	1
PRT	0.075	29	28	0.042	24	25	0.042	28	28	-0.004	5	5	0	35	35	-0.003	7	7
ROU	0.108	38	37	0.077	34	34	0.076	34	34	-0.004	3	4	0	28	30	-0.003	4	6
RUS	0.081	31	31	0.057	31	31	0.045	30	29	-0.003	8	9	-0.004	5	5	-0.003	5	4
SWE	0.037	5	5	0.03	8	7	0.028	6	6	-0.001	33	33	-0.001	24	29	-0.001	35	35
THA	0.108	37	38	0.132	39	39	0.107	38	38	0.003	39	39	-0.008	1	1	0	38	38
USA	0.056	24	22	0.038	23	20	0.034	19	16	-0.002	14	17	-0.001	13	14	-0.002	12	12

Atkinson's Inequality Measures (AIM) reflect the inequality of the HMW distribution, and are computed for coefficient $\varepsilon = 1$. Columns (1), (4) and (7) present the AIM(1) for the relevant country-year. The associated rankings are displayed in the column to the right where lower ranking value indicates lower levels of AIM(1) inequality. Columns (3), (6) and (9) present the rankings by the Gini coefficient of national incomes. Columns (10), (13) and (16) display the annualised change in AIM(1) for each country-year, with the two columns to the right reporting the associated rankings across countries, as well as the ranking over annualised changes in the Gini coefficient of household durables.

Table 5b: AIM(2) Values and Rankings, by Year and Levels/Changes

	2000 Levels			2009 Levels			2012 Levels			00-09 Annual Δ			09-12 Annual Δ			00-12 Annual Δ		
	AIM	AIM Rank	Gini Rank	AIM	AIM Rank	Gini Rank	AIM	AIM Rank	Gini Rank	dAIM	dAIM Rank	Δ Gini Rank	dAIM	dAIM Rank	Δ Gini Rank	dAIM	dAIM Rank	Δ Gini Rank
ALB	0.129	27	29	0.161	36	36	0.158	36	36	0.005	38	38	-0.001	28	19	0.003	39	39
ARG	0.18	35	36	0.16	35	35	0.134	33	33	-0.003	23	20	-0.009	4	3	-0.005	8	5
AUS	0.101	15	11	0.067	14	10	0.064	14	11	-0.004	16	16	-0.001	27	27	-0.003	17	20
AUT	0.088	8	9	0.068	16	16	0.062	11	14	-0.002	29	28	-0.002	15	21	-0.002	29	29
BEL	0.089	10	12	0.066	13	13	0.06	9	10	-0.003	26	19	-0.002	17	16	-0.002	23	14
BGR	0.129	26	26	0.125	32	32	0.115	32	32	-0.001	35	31	-0.003	10	11	-0.001	34	26
BRA	0.205	38	39	0.21	38	37	0.175	37	37	0.001	36	35	-0.012	2	2	-0.002	24	13
CAN	0.105	17	16	0.077	21	18	0.072	23	19	-0.003	20	22	-0.002	22	18	-0.003	21	25
CHE	0.098	13	17	0.062	7	9	0.059	6	9	-0.004	13	12	-0.001	26	26	-0.003	13	11
CHL	0.174	34	35	0.134	33	33	0.154	35	35	-0.006	7	7	0.006	40	39	-0.002	30	15
CZE	0.131	28	27	0.075	20	22	0.075	24	25	-0.006	6	6	0	32	34	-0.005	7	8
DEU	0.105	16	18	0.079	22	23	0.066	15	15	-0.003	22	26	-0.004	9	9	-0.003	15	19
DNK	0.081	6	6	0.059	6	4	0.054	4	4	-0.002	27	24	-0.002	21	32	-0.002	27	30
ESP	0.116	24	25	0.096	28	28	0.07	21	22	-0.002	30	23	-0.009	5	4	-0.004	11	10
FIN	0.081	7	7	0.052	4	5	0.059	8	13	-0.003	19	21	0.002	37	37	-0.002	32	32
FRA	0.107	19	14	0.073	17	17	0.067	18	17	-0.004	14	25	-0.002	19	22	-0.003	12	28
GBR	0.105	18	21	0.073	18	21	0.069	19	23	-0.004	17	18	-0.002	23	24	-0.003	16	22
GRC	0.109	21	24	0.084	25	26	0.075	26	26	-0.003	25	29	-0.003	13	10	-0.003	20	23
HKG	0.089	9	10	0.083	24	27	0.067	16	24	-0.001	34	37	-0.005	7	6	-0.002	28	31
HUN	0.162	32	33	0.085	27	24	0.081	27	27	-0.009	2	1	-0.001	25	31	-0.007	2	2
IDN	0.151	29	30	0.208	37	38	0.194	38	39	0.008	39	40	-0.005	8	7	0.004	40	40
IRL	0.11	23	23	0.065	12	14	0.058	5	7	-0.005	8	8	-0.002	18	13	-0.004	9	9
ISL	0.071	1	2	0.05	2	2	0.06	10	8	-0.002	28	27	0.004	38	40	-0.001	35	37
ITA	0.092	12	13	0.064	11	12	0.064	12	12	-0.003	21	15	0	31	23	-0.002	26	17
JPN	0.098	14	15	0.073	19	19	0.067	17	18	-0.003	24	30	-0.002	16	15	-0.003	22	27
KOR	0.09	11	8	0.056	5	3	0.053	3	2	-0.004	15	14	-0.001	29	28	-0.003	18	18
LIE	0.071	2	3	0.052	3	6	0.048	2	3	-0.002	31	32	-0.001	24	17	-0.002	31	33
LUX	0.108	20	19	0.064	9	11	0.075	25	20	-0.005	9	10	0.004	39	38	-0.003	19	24

(Continued)

Table 5b: AIM(2) Values and Rankings, by Year and Levels/Changes (continued)

	2000 Levels			2009 Levels			2012 Levels			00-09 Annual Δ			09-12 Annual Δ			00-12 Annual Δ		
	AIM	AIM Rank	Gini Rank	AIM	AIM Rank	Gini Rank	AIM	AIM Rank	Gini Rank	dAIM	dAIM Rank	Δ Gini Rank	dAIM	dAIM Rank	Δ Gini Rank	dAIM	dAIM Rank	Δ Gini Rank
LVA	0.165	33	32	0.096	29	29	0.089	29	30	-0.008	4	3	-0.002	14	20	-0.006	3	3
MEX	0.244	40	40	0.276	40	40	0.253	40	40	0.004	37	36	-0.008	6	8	0.001	37	34
NLD	0.071	3	4	0.042	1	1	0.043	1	1	-0.003	18	13	0	33	33	-0.002	25	21
NOR	0.073	4	1	0.062	8	8	0.064	13	5	-0.001	33	34	0.001	34	25	-0.001	36	36
NZL	0.109	22	20	0.068	15	15	0.07	20	21	-0.005	11	11	0.001	36	36	-0.003	14	16
POL	0.187	36	34	0.104	30	30	0.094	31	31	-0.009	1	2	-0.003	11	12	-0.008	1	1
PRT	0.151	30	28	0.084	26	25	0.086	28	28	-0.007	5	5	0.001	35	35	-0.005	6	7
ROU	0.21	39	37	0.156	34	34	0.153	34	34	-0.008	3	4	-0.001	30	30	-0.006	5	6
RUS	0.158	31	31	0.116	31	31	0.089	30	29	-0.005	10	9	-0.009	3	5	-0.006	4	4
SWE	0.077	5	5	0.064	10	7	0.059	7	6	-0.001	32	33	-0.002	20	29	-0.002	33	35
THA	0.192	37	38	0.255	39	39	0.214	39	38	0.009	40	39	-0.014	1	1	0.002	38	38
USA	0.12	25	22	0.081	23	20	0.072	22	16	-0.004	12	17	-0.003	12	14	-0.004	10	12

Atkinson's Inequality Measures (AIM) reflect the inequality of the HMW distribution, and are computed for coefficient $\varepsilon = 2$. Columns (1), (4) and (7) present the AIM(2) for the relevant country-year. The associated rankings are displayed in the column to the right where lower ranking value indicates lower levels of AIM(1) inequality. Columns (3), (6) and (9) present the rankings by the Gini coefficient of national incomes. Columns (10), (13) and (16) display the annualised change in AIM(2) for each country-year, with the two columns to the right reporting the associated rankings across countries, as well as the ranking over annualised changes in the Gini coefficient of household durables.

Table 5c: AIM(3) Values and Rankings, by Year and Levels/Changes

	2000 Levels			2009 Levels			2012 Levels			00-09 Annual Δ			09-12 Annual Δ			00-12 Annual Δ		
	AIM	AIM Rank	Gini Rank	AIM	AIM Rank	Gini Rank	AIM	AIM Rank	Gini Rank	dAIM	dAIM Rank	Δ Gini Rank	dAIM	dAIM Rank	Δ Gini Rank	dAIM	dAIM Rank	Δ Gini Rank
ALB	0.176	23	29	0.231	34	36	0.229	35	36	0.008	38	38	0	30	19	0.005	39	39
ARG	0.248	35	36	0.231	35	35	0.204	33	33	-0.002	29	20	-0.009	6	3	-0.004	18	5
AUS	0.165	17	11	0.131	26	10	0.112	19	11	-0.004	22	16	-0.006	10	27	-0.004	17	20
AUT	0.134	9	9	0.112	13	16	0.094	9	14	-0.002	28	28	-0.006	12	21	-0.003	24	29
BEL	0.132	8	12	0.13	24	13	0.094	8	10	0	34	19	-0.012	5	16	-0.003	27	14
BGR	0.19	24	26	0.204	33	32	0.196	32	32	0.002	35	31	-0.003	21	11	0.001	36	26
BRA	0.276	37	39	0.3	38	37	0.26	37	37	0.003	36	35	-0.013	3	2	-0.001	31	13
CAN	0.173	21	16	0.127	21	18	0.134	27	19	-0.005	19	22	0.002	33	18	-0.003	26	25
CHE	0.148	13	17	0.097	6	9	0.09	6	9	-0.006	16	12	-0.002	24	26	-0.005	14	11
CHL	0.24	33	35	0.19	32	33	0.228	34	35	-0.007	11	7	0.013	40	39	-0.001	33	15
CZE	0.193	26	27	0.126	19	22	0.121	23	25	-0.007	10	6	-0.002	28	34	-0.006	11	8
DEU	0.207	27	18	0.126	20	23	0.107	16	15	-0.009	7	26	-0.006	9	9	-0.008	5	19
DNK	0.124	7	6	0.099	7	4	0.08	3	4	-0.003	27	24	-0.006	11	32	-0.004	22	30
ESP	0.171	20	25	0.158	30	28	0.11	18	22	-0.001	31	23	-0.016	1	4	-0.005	12	10
FIN	0.122	5	7	0.077	3	5	0.089	5	13	-0.005	20	21	0.004	37	37	-0.003	29	32
FRA	0.216	28	14	0.115	16	17	0.103	13	17	-0.011	3	25	-0.004	18	22	-0.009	2	28
GBR	0.159	15	21	0.111	12	21	0.103	15	23	-0.005	17	18	-0.003	23	24	-0.005	16	22
GRC	0.163	16	24	0.129	22	26	0.117	22	26	-0.004	23	29	-0.004	19	10	-0.004	21	23
HKG	0.135	10	10	0.119	18	27	0.095	10	24	-0.002	30	37	-0.008	8	6	-0.004	20	31
HUN	0.233	32	33	0.132	27	24	0.124	25	27	-0.011	2	1	-0.003	22	31	-0.009	3	2
IDN	0.226	29	30	0.278	37	38	0.274	38	39	0.007	37	40	-0.001	29	7	0.005	38	40
IRL	0.167	18	23	0.1	8	14	0.09	7	7	-0.007	9	8	-0.003	20	13	-0.006	9	9
ISL	0.11	3	2	0.08	4	2	0.097	11	8	-0.003	25	27	0.006	38	40	-0.001	34	37
ITA	0.138	11	13	0.112	15	12	0.122	24	12	-0.003	26	15	0.003	36	23	-0.001	32	17
JPN	0.154	14	15	0.116	17	19	0.103	14	18	-0.004	21	30	-0.004	17	15	-0.004	19	27
KOR	0.139	12	8	0.087	5	3	0.082	4	2	-0.006	15	14	-0.002	26	28	-0.005	15	18
LIE	0.109	2	3	0.077	2	6	0.071	2	3	-0.004	24	32	-0.002	25	17	-0.003	28	33
LUX	0.174	22	19	0.101	9	11	0.132	26	20	-0.008	8	10	0.01	39	38	-0.003	23	24

(Continued)

Table 5c: AIM(3) Values and Rankings, by Year and Levels/Changes (continued)

	2000 Levels			2009 Levels			2012 Levels			00-09 Annual Δ			09-12 Annual Δ			00-12 Annual Δ		
	AIM	AIM Rank	Gini Rank	AIM	AIM Rank	Gini Rank	AIM	AIM Rank	Gini Rank	dAIM	dAIM Rank	Δ Gini Rank	dAIM	dAIM Rank	Δ Gini Rank	dAIM	dAIM Rank	Δ Gini Rank
LVA	0.241	34	32	0.151	28	29	0.136	29	30	-0.01	5	3	-0.005	14	20	-0.009	4	3
MEX	0.323	40	40	0.394	40	40	0.368	40	40	0.008	39	36	-0.009	7	8	0.004	37	34
NLD	0.109	1	4	0.062	1	1	0.069	1	1	-0.005	18	13	0.002	34	33	-0.003	25	21
NOR	0.117	4	1	0.105	10	8	0.115	21	5	-0.001	32	34	0.003	35	25	0	35	36
NZL	0.169	19	20	0.107	11	15	0.109	17	21	-0.007	12	11	0.001	31	36	-0.005	13	16
POL	0.277	38	34	0.158	29	30	0.144	31	31	-0.013	1	2	-0.005	16	12	-0.011	1	1
PRT	0.227	30	28	0.129	23	25	0.135	28	28	-0.011	4	5	0.002	32	35	-0.008	7	7
ROU	0.305	39	37	0.238	36	34	0.233	36	34	-0.01	6	4	-0.002	27	30	-0.007	8	6
RUS	0.231	31	31	0.178	31	31	0.137	30	29	-0.006	14	9	-0.013	4	5	-0.008	6	4
SWE	0.123	6	5	0.112	14	7	0.097	12	6	-0.001	33	33	-0.005	15	29	-0.002	30	35
THA	0.257	36	38	0.36	39	39	0.316	39	38	0.015	40	39	-0.015	2	1	0.006	40	38
USA	0.19	25	22	0.13	25	20	0.114	20	16	-0.007	13	17	-0.005	13	14	-0.006	10	12

Atkinson's Inequality Measures (AIM) reflect the inequality of the HMW distribution, and are computed for coefficient $\varepsilon = 3$. Columns (1), (4) and (7) present the AIM(3) for the relevant country-year. The associated rankings are displayed in the column to the right where lower ranking value indicates lower levels of AIM(1) inequality. Columns (3), (6) and (9) present the rankings by the Gini coefficient of national incomes. Columns (10), (13) and (16) display the annualised change in AIM(3) for each country-year, with the two columns to the right reporting the associated rankings across countries, as well as the ranking over annualised changes in the Gini coefficient of household durables.

Table 6a: IMWI(1) Values and Rankings, by Year and Levels/Changes

	2000 Levels		2009 Levels		2012 Levels		00-09 Annual %Δ		09-12 Annual %Δ		00-12 Annual %Δ	
	IMWI	Rank	IMWI	Rank	IMWI	Rank	IMWI	Rank	IMWI	Rank	IMWI	Rank
ALB	1757	38	2380	36	2539	38	4.42	9	2.18	8	3.75	9
ARG	2150	31	2559	34	2707	35	2.52	19	1.89	10	2.33	14
AUS	3995	2	4676	4	4718	4	1.76	31	0.29	27	1.39	34
AUT	3526	11	4191	14	4248	11	1.94	28	0.45	23	1.56	28
BEL	3133	23	4028	18	4089	20	2.83	15	0.5	22	2.24	16
BGR	2334	27	3367	28	3505	27	5.38	4	1.35	13	4.15	7
BRA	1844	37	2288	38	2644	36	2.43	20	4.94	4	3.05	11
CAN	3960	3	4687	3	4744	2	1.89	29	0.41	26	1.52	31
CHE	3309	17	4037	17	4133	16	2.23	25	0.79	18	1.87	23
CHL	2018	32	2801	32	3289	30	4.79	6	5.5	2	5.01	2
CZE	2447	26	3659	25	3808	24	4.57	8	1.34	14	3.76	8
DEU	3466	14	4013	19	4161	15	1.64	34	1.22	15	1.53	30
DNK	3468	13	3978	20	4028	22	1.53	36	0.42	25	1.25	35
ESP	3170	20	3861	23	4091	19	2.22	26	1.95	9	2.15	17
FIN	3520	12	4330	11	4234	12	2.33	22	-0.74	37	1.55	29
FRA	3139	22	4038	16	4129	17	2.84	14	0.75	20	2.31	15
GBR	3406	15	4114	15	4230	13	2.12	27	0.93	16	1.82	25
GRC	2843	24	3901	22	3877	23	3.58	12	-0.2	36	2.62	13
HKG	2216	30	2135	39	2564	37	-0.53	40	6.3	1	1.47	32
HUN	2263	29	3428	27	3459	28	4.72	7	0.29	28	3.6	10
IDN	1291	40	1412	40	1552	40	1.29	38	3.22	6	1.86	24
IRL	3175	19	4492	6	4470	7	3.93	10	-0.16	35	2.89	12
ISL	3828	5	4461	8	4214	14	1.72	32	-1.88	40	0.81	40
ITA	3651	9	4310	12	4341	10	1.86	30	0.24	30	1.45	33
JPN	3398	16	3753	24	3786	26	1.11	39	0.29	29	0.9	39
KOR	2647	25	3326	29	3377	29	2.57	18	0.5	21	2.05	21
LIE	3602	10	4407	9	4642	5	2.26	23	1.75	11	2.14	19
LUX	3688	8	4505	5	4496	6	2.25	24	-0.07	33	1.66	27
LVA	2017	33	3244	30	3287	31	5.42	3	0.44	24	4.15	6
MEX	1924	35	2377	37	2432	39	2.38	21	0.77	19	1.97	22
NLD	3152	21	3969	21	4066	21	2.6	17	0.81	17	2.14	18
NOR	3859	4	4475	7	4461	8	1.66	33	-0.11	34	1.21	36
NZL	3821	7	4849	2	4739	3	2.68	16	-0.76	38	1.81	26
POL	2292	28	3519	26	3805	25	4.88	5	2.63	7	4.32	4
PRT	3186	18	4208	13	4100	18	3.14	13	-0.86	39	2.12	20
ROU	1869	36	2746	33	2869	34	5.65	2	1.46	12	4.38	3
RUS	1676	39	2801	31	3088	32	5.87	1	3.31	5	5.22	1
SWE	3827	6	4400	10	4414	9	1.56	35	0.1	31	1.2	37
THA	1952	34	2541	35	2962	33	3.84	11	5.25	3	4.26	5
USA	4330	1	4896	1	4902	1	1.38	37	0.04	32	1.04	38

Columns (1), (3) and (5) present the IMWI value for the relevant country-year where $\varepsilon=1$, where the associated rankings are displayed in the column to the right where lower ranking values indicate higher levels of IMWI. Columns (7), (9) and (11) display the annualised IMWI percentage growth rates for each country-period, with the associated rankings to the right.

Table 6b: IMWI(2) Values and Rankings, by Year and Levels/Changes

	2000 Levels		2009 Levels		2012 Levels		00-09 Annual %Δ		09-12 Annual %Δ		00-12 Annual %Δ	
	IMWI	Rank	IMWI	Rank	IMWI	Rank	IMWI	Rank	IMWI	Rank	IMWI	Rank
ALB	1647	38	2181	36	2328	38	4.09	10	2.2	10	3.52	10
ARG	1952	31	2343	34	2514	35	2.64	19	2.38	9	2.56	14
AUS	3772	2	4502	3	4552	4	1.99	30	0.36	29	1.58	33
AUT	3364	12	4039	13	4112	11	2.05	28	0.6	22	1.69	28
BEL	2990	19	3885	18	3961	19	2.95	16	0.64	21	2.37	17
BGR	2177	27	3136	29	3284	28	5.36	5	1.54	12	4.2	6
BRA	1655	36	2030	38	2395	37	2.3	26	5.67	3	3.13	12
CAN	3731	3	4490	4	4557	3	2.08	27	0.49	26	1.68	29
CHE	3138	17	3907	16	4008	16	2.47	22	0.85	19	2.06	22
CHL	1841	32	2610	32	3017	31	5.11	7	4.96	4	5.06	2
CZE	2279	26	3515	25	3659	24	4.93	8	1.35	15	4.02	7
DEU	3266	14	3844	21	4015	15	1.83	33	1.46	14	1.74	27
DNK	3322	13	3855	20	3919	21	1.67	35	0.56	25	1.39	35
ESP	2979	21	3660	23	3940	20	2.31	25	2.49	8	2.36	18
FIN	3371	11	4216	11	4106	12	2.52	21	-0.88	38	1.66	30
FRA	2948	22	3880	19	3984	17	3.1	13	0.88	18	2.54	15
GBR	3216	16	3957	15	4079	14	2.33	24	1.02	17	2	24
GRC	2682	24	3733	22	3726	23	3.74	11	-0.06	34	2.78	13
HKG	2118	28	2049	37	2482	36	-0.47	40	6.59	1	1.6	32
HUN	2071	29	3274	27	3311	27	5.22	6	0.38	28	3.99	8
IDN	1191	40	1271	40	1403	40	0.94	39	3.34	6	1.65	31
IRL	2988	20	4339	7	4333	6	4.23	9	-0.05	33	3.15	11
ISL	3685	5	4347	6	4080	13	1.85	32	-2.09	40	0.85	40
ITA	3476	8	4163	12	4191	10	2.02	29	0.22	32	1.57	34
JPN	3217	15	3607	24	3653	25	1.28	38	0.43	27	1.06	39
KOR	2519	25	3228	28	3283	29	2.79	17	0.56	24	2.23	21
LIE	3469	9	4291	9	4529	5	2.39	23	1.82	11	2.25	20
LUX	3468	10	4354	5	4309	7	2.56	20	-0.34	36	1.83	25
LVA	1840	33	3078	30	3133	30	5.88	3	0.6	23	4.54	5
MEX	1687	35	2005	39	2084	39	1.94	31	1.3	16	1.78	26
NLD	3035	18	3886	17	3978	18	2.78	18	0.78	20	2.28	19
NOR	3709	4	4326	8	4302	8	1.72	34	-0.19	35	1.24	38
NZL	3594	7	4673	2	4562	2	2.96	15	-0.79	37	2.01	23
POL	2060	30	3326	26	3618	26	5.47	4	2.84	7	4.8	3
PRT	2924	23	4020	14	3911	22	3.6	12	-0.91	39	2.45	16
ROU	1655	37	2512	33	2628	33	6.14	2	1.52	13	4.74	4
RUS	1536	39	2627	31	2944	32	6.15	1	3.86	5	5.57	1
SWE	3669	6	4247	10	4276	9	1.64	37	0.22	31	1.28	37
THA	1767	34	2182	35	2607	34	3.05	14	6.12	2	3.96	9
USA	4038	1	4678	1	4710	1	1.65	36	0.23	30	1.29	36

Columns (1), (3) and (5) present the IMWI value for the relevant country-year where $\varepsilon=2$, where the associated rankings are displayed in the column to the right where lower ranking values indicate higher levels of IMWI. Columns (7), (9) and (11) display the annualised IMWI percentage growth rates for each country-period, with the associated rankings to the right.

Table 6c: IMWI(3) Values and Rankings, by Year and Levels/Changes

	2000 Levels		2009 Levels		2012 Levels		00-09 Annual %Δ		09-12 Annual %Δ		00-12 Annual %Δ	
	IMWI	Rank	IMWI	Rank	IMWI	Rank	IMWI	Rank	IMWI	Rank	IMWI	Rank
ALB	1557	35	2000	35	2132	38	3.64	13	2.14	10	3.19	12
ARG	1791	31	2147	34	2310	35	2.62	21	2.47	9	2.57	16
AUS	3501	4	4193	5	4318	4	2.03	29	0.98	23	1.76	31
AUT	3194	12	3852	13	3971	11	2.1	27	1.02	21	1.83	27
BEL	2850	19	3622	21	3819	19	2.7	19	1.79	12	2.47	18
BGR	2023	27	2852	30	2983	29	5.03	8	1.51	17	3.96	8
BRA	1506	37	1798	38	2149	37	1.99	31	6.13	3	3.01	13
CAN	3446	6	4247	3	4255	5	2.35	25	0.06	33	1.77	29
CHE	2965	16	3759	17	3874	15	2.67	20	1.01	22	2.25	23
CHL	1695	32	2441	32	2751	32	5.35	6	4.07	5	4.96	4
CZE	2117	26	3321	25	3475	25	5.13	7	1.52	16	4.22	7
DEU	2892	18	3646	20	3841	17	2.61	22	1.75	13	2.39	21
DNK	3166	13	3689	19	3810	20	1.71	35	1.08	20	1.55	33
ESP	2793	21	3409	24	3771	21	2.24	26	3.42	6	2.53	17
FIN	3220	10	4107	10	3974	10	2.74	18	-1.08	38	1.77	30
FRA	2589	23	3704	18	3831	18	4.06	11	1.14	19	3.32	11
GBR	3025	14	3795	16	3927	13	2.55	24	1.15	18	2.2	25
GRC	2518	24	3549	22	3558	23	3.89	12	0.08	32	2.92	14
HKG	2011	28	1969	36	2405	33	-0.3	40	6.91	1	1.81	28
HUN	1895	29	3105	28	3157	28	5.64	5	0.56	28	4.35	6
IDN	1086	40	1160	40	1263	40	0.94	39	2.89	8	1.52	34
IRL	2796	20	4174	8	4185	6	4.55	9	0.09	31	3.42	9
ISL	3527	3	4208	4	3922	14	1.98	32	-2.32	40	0.89	40
ITA	3298	9	3950	12	3928	12	2.02	30	-0.18	34	1.47	35
JPN	3018	15	3443	23	3512	24	1.47	37	0.67	25	1.27	38
KOR	2384	25	3121	27	3183	27	3.04	15	0.65	26	2.44	19
LIE	3328	8	4180	6	4421	2	2.56	23	1.89	11	2.39	20
LUX	3213	11	4179	7	4043	9	2.97	17	-1.1	39	1.93	26
LVA	1671	33	2892	29	2972	30	6.29	3	0.9	24	4.91	5
MEX	1510	36	1678	39	1763	39	1.18	38	1.65	14	1.3	37
NLD	2914	17	3805	15	3869	16	3.01	16	0.56	29	2.39	22
NOR	3531	2	4129	9	4068	8	1.75	34	-0.49	35	1.19	39
NZL	3354	7	4478	1	4371	3	3.27	14	-0.8	36	2.23	24
POL	1834	30	3126	26	3418	26	6.1	4	3.02	7	5.32	2
PRT	2660	22	3823	14	3703	22	4.11	10	-1.06	37	2.79	15
ROU	1458	38	2269	33	2381	34	6.53	1	1.62	15	5.03	3
RUS	1403	39	2444	31	2788	31	6.36	2	4.49	4	5.89	1
SWE	3486	5	4031	11	4100	7	1.63	36	0.57	27	1.36	36
THA	1625	34	1873	37	2269	36	2.05	28	6.61	2	3.4	10
USA	3715	1	4428	2	4494	1	1.97	33	0.5	30	1.6	32

Columns (1), (3) and (5) present the IMWI value for the relevant country-year where $\varepsilon=1$, where the associated rankings are displayed in the column to the right where lower ranking values indicate higher levels of IMWI. Columns (7), (9) and (11) display the annualised IMWI percentage growth rates for each country-period, with the associated rankings to the right.

Table 7: Multivariate MWI Regressions, by Year, Dependent Variable: lnMWI

	Simple Model			Full Model			Simple Model plus Credit		
	2000	2009	2012	2000	2009	2012	2000	2009	2012
lnGNIpc	1.8970**	3.9626***	4.1597***	2.3191	4.2245***	2.3340*	1.3040	3.7363***	3.9909***
	(0.8773)	(0.9100)	(0.9754)	(1.7088)	(1.0263)	(1.2897)	(1.0250)	(0.8554)	(0.9593)
$(lnGNIpc)^2$	-0.0749*	-0.1770***	-0.1872***	-0.0935	-0.1906***	-0.1030	-0.0444	-0.1660***	-0.1791***
	(0.0442)	(0.0450)	(0.0479)	(0.0848)	(0.0500)	(0.0617)	(0.0520)	(0.0423)	(0.0471)
Gini				-0.1113	0.2135	0.1972			
				(0.4197)	(0.3233)	(0.3002)			
Credit				0.0232**	0.0155*	0.0100	0.0199**	0.0177**	0.0120
				(0.0108)	(0.0081)	(0.0069)	(0.0087)	(0.0073)	(0.0075)
Demog				1.3231	0.2658	0.9230			
				(1.4006)	(0.8124)	(0.7709)			
lnTranspc				-0.0258	0.0284	0.0407			
				(0.0563)	(0.0390)	(0.0345)			
Constant	-3.4798	-13.7337***	-14.6665***	-6.2741	-15.5121***	-5.6382	-0.7409	-12.6859***	-13.8741***
	(4.3412)	(4.5947)	(4.9607)	(8.6603)	(5.2243)	(6.6736)	(5.0411)	(4.3152)	(4.8742)
N	37	37	37	31	35	33	36	37	37
R-sq	0.8431	0.8372	0.8034	0.8869	0.8622	0.7378	0.8708	0.8620	0.8177

The dependent variable across all regressions is lnMWI. Row headers are as follows: Gini denotes the Gini coefficient of household incomes series, derived from World Bank and OECD database entries; Credit denotes the strength of legal rights index, available through the World Bank's Doing Business project; Demog denotes a series of the share of the population aged 20-64; and lnTranspc denotes the log-transformed series of government transfers per capita, derived from World Bank data.

Note the maximum number of country-year observations is 37, as we exclude Hong Kong because it is an outlier in the relationship between MWI and GNIpc, while Argentina, and Liechtenstein are missing GNI estimates in all years. The variation in sample sizes across models is explained by the following: in 2000, Portugal, Korea and Iceland are missing Gini estimates, whilst Luxembourg is missing Credit data and Japan is missing government transfers data; in 2009, both Albania and Mexico are missing transfers data; and for 2012, Japan is missing Gini estimates, whilst Mexico, Albania and Indonesia are missing transfers data.

Table 8: MWI Beta-Convergence Regressions, by Year

	2000-2009			2009-2012			2000-2012		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Lagged lnMWI	-0.0300***	-0.0174	-0.0147	-0.0399***	-0.0302*	-0.0264	-0.0306***	-0.0232**	-0.0222**
	(0.0053)	(0.0107)	(0.0094)	(0.0076)	(0.0161)	(0.0174)	(0.0042)	(0.0097)	(0.0086)
Lagged lnGNIpc		0.0053	0.0017		-0.0014	0.0002		0.0029	-0.0001
		(0.0054)	(0.0052)		(0.0069)	(0.0074)		(0.0048)	(0.0044)
dlnGNIpc		0.5307***	0.4223***		0.1925*	0.1914*		0.3322**	0.2471**
		(0.1213)	(0.1277)		(0.1005)	(0.1014)		(0.1285)	(0.1184)
Lagged AIM(1)			0.0703			0.0101			-0.0018
			(0.0774)			(0.1377)			(0.0690)
dAIM(1)			-2.1429***			-1.2358			-3.2814***
			(0.6625)			(1.2810)			(0.9139)
Constant	0.2676***	0.1028*	0.1124	0.3381***	0.2690***	0.2190*	0.2676***	0.1725***	0.1925***
	(0.0427)	(0.0566)	(0.0787)	(0.0628)	(0.0850)	(0.1217)	(0.0336)	(0.0539)	(0.0659)
N	39	37	37	39	37	37	39	37	37
r2	0.4624	0.6775	0.8028	0.4265	0.5138	0.5371	0.5906	0.6819	0.7983

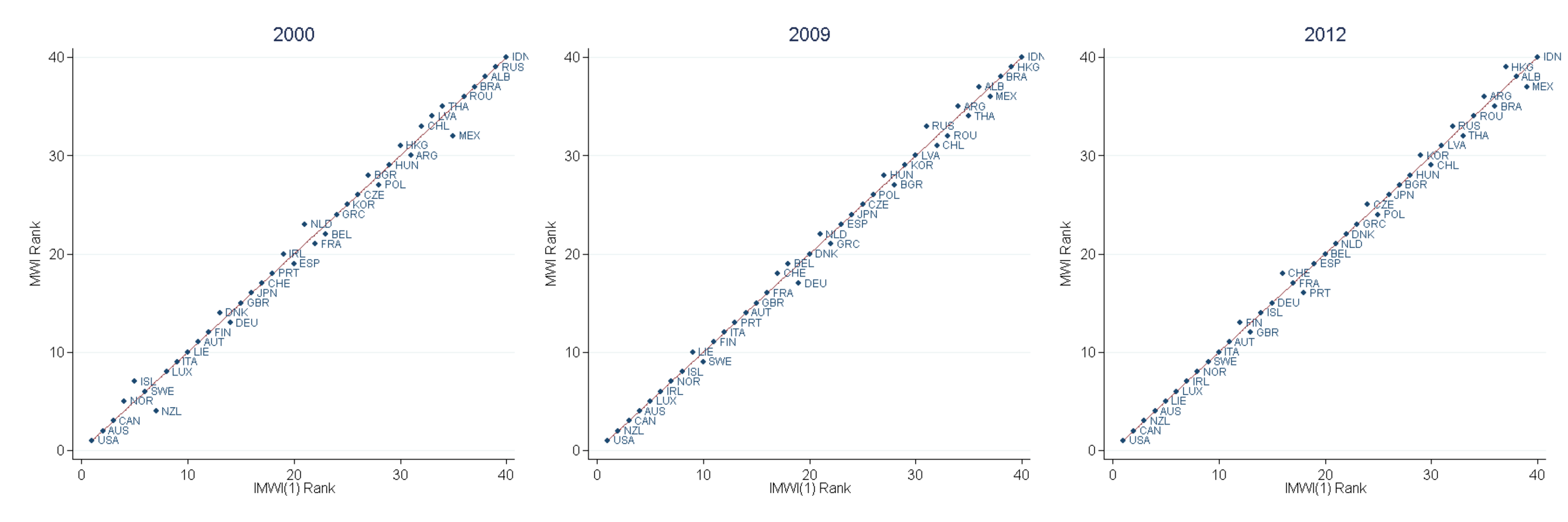
The dependent variable across all regressions is dlnMWI, the change in lnMWI over the regression period. Row headers are as follows: Lagged lnMWI, Lagged lnGNIpc and Lagged AIM(1) denote the levels of lnMWI, lnGNIpc and AIM(1) at the start of the period, respectively; and dlnGNIpc and dAIM(1) are the coefficients of the change in lnGNIpc and AIM(1) over the regression period, respectively.

Note we consider a maximum sample size for the Beta-convergence regressions of 39, excluding Hong Kong as it is an outlier in the relationship between MWI and GNIpc. Argentina, and Liechtenstein are missing GNI estimates in all years which reduces the sample size of other columns.

Table 9: Australian Expenditure Weighted Pseudo-MWI Values, by Year

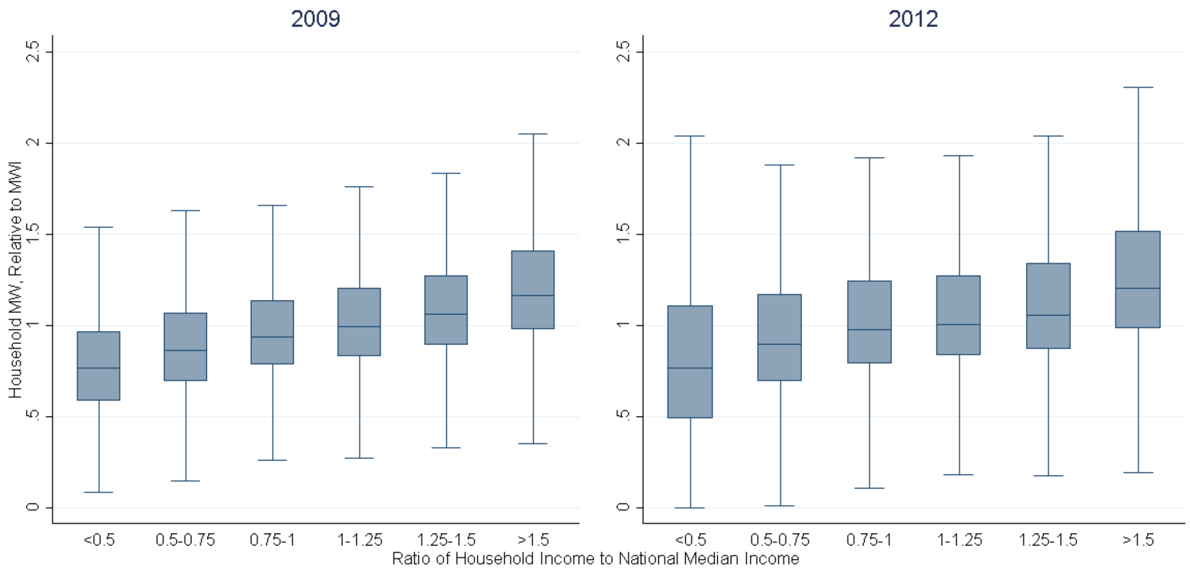
	2000			2009			2012		
	MWI_{AUS}	AIM_{AUS}	$IMWI_{AUS}$	MWI_{AUS}	AIM_{AUS}	$IMWI_{AUS}$	MWI_{AUS}	AIM_{AUS}	$IMWI_{AUS}$
ALB	1818	0.081	1672	3110	0.073	2884	3395	0.072	3151
ARG	2320	0.12	2041	3395	0.079	3125	3824	0.056	3609
AUS	4135	0.052	3918	5362	0.019	5260	5435	0.019	5334
AUT	3851	0.048	3666	5123	0.019	5028	5199	0.016	5117
BEL	3303	0.059	3107	4998	0.02	4899	5117	0.017	5029
BGR	2437	0.086	2227	4413	0.047	4204	4631	0.041	4440
BRA	1897	0.139	1632	3100	0.114	2746	3663	0.078	3378
CAN	3844	0.055	3633	5243	0.027	5102	5413	0.023	5291
CHE	3548	0.06	3336	4974	0.019	4881	5101	0.016	5018
CHL	2454	0.116	2170	3853	0.061	3620	4483	0.051	4256
CZE	2476	0.08	2278	4674	0.022	4573	4891	0.019	4795
DEU	3673	0.059	3456	5058	0.024	4936	5186	0.019	5087
DNK	4463	0.039	4291	5334	0.016	5247	5415	0.014	5340
ESP	3252	0.068	3032	4827	0.028	4690	5104	0.021	4995
FIN	4204	0.042	4029	5399	0.013	5329	5435	0.014	5359
FRA	3137	0.058	2956	4809	0.026	4682	4969	0.021	4867
GBR	3875	0.052	3673	5146	0.018	5053	5248	0.017	5161
GRC	2931	0.068	2732	4677	0.029	4541	4797	0.026	4672
HKG	3393	0.049	3228	3750	0.027	3650	4116	0.023	4023
HUN	2369	0.091	2153	4590	0.029	4457	4691	0.025	4573
IDN	1299	0.103	1165	2038	0.135	1762	2394	0.12	2105
IRL	3423	0.055	3234	5157	0.017	5070	5289	0.015	5210
ISL	4420	0.033	4274	5506	0.013	5434	5391	0.014	5313
ITA	3762	0.051	3570	5072	0.022	4962	5213	0.019	5112
JPN	3537	0.049	3365	4354	0.026	4239	4451	0.02	4360
KOR	3248	0.056	3067	4274	0.018	4198	4334	0.017	4259
LIE	3784	0.042	3626	5213	0.015	5137	5530	0.012	5462
LUX	3892	0.062	3651	5409	0.017	5317	5440	0.02	5332
LVA	2007	0.085	1837	4223	0.031	4094	4376	0.027	4259
MEX	1958	0.154	1656	3018	0.145	2580	3216	0.128	2805
NLD	3741	0.046	3570	5185	0.011	5125	5288	0.012	5227
NOR	4449	0.034	4297	5592	0.015	5510	5565	0.016	5475
NZL	3890	0.058	3665	5410	0.023	5288	5421	0.023	5295
POL	2322	0.11	2068	4488	0.034	4335	4846	0.027	4714
PRT	3306	0.085	3025	5154	0.025	5027	5144	0.025	5016
ROU	2065	0.139	1778	3921	0.061	3682	4034	0.064	3775
RUS	1591	0.081	1463	3829	0.048	3646	4301	0.027	4184
SWE	4502	0.038	4331	5478	0.016	5389	5521	0.014	5443
THA	2017	0.125	1764	3364	0.108	3002	3847	0.079	3543
USA	4143	0.063	3884	5336	0.031	5169	5378	0.026	5237

Figure 1: MWI vs IMWI(1) Rankings, by Year



The figure plots the ranking of country-year observations by MWI on the y-axis, and by IMWI(1) on the x-axis - the 45° line depicted shows where rankings are equivalent across constructions.

Figure 2: Household-level Material Wellbeing (MW) and Income, by Year



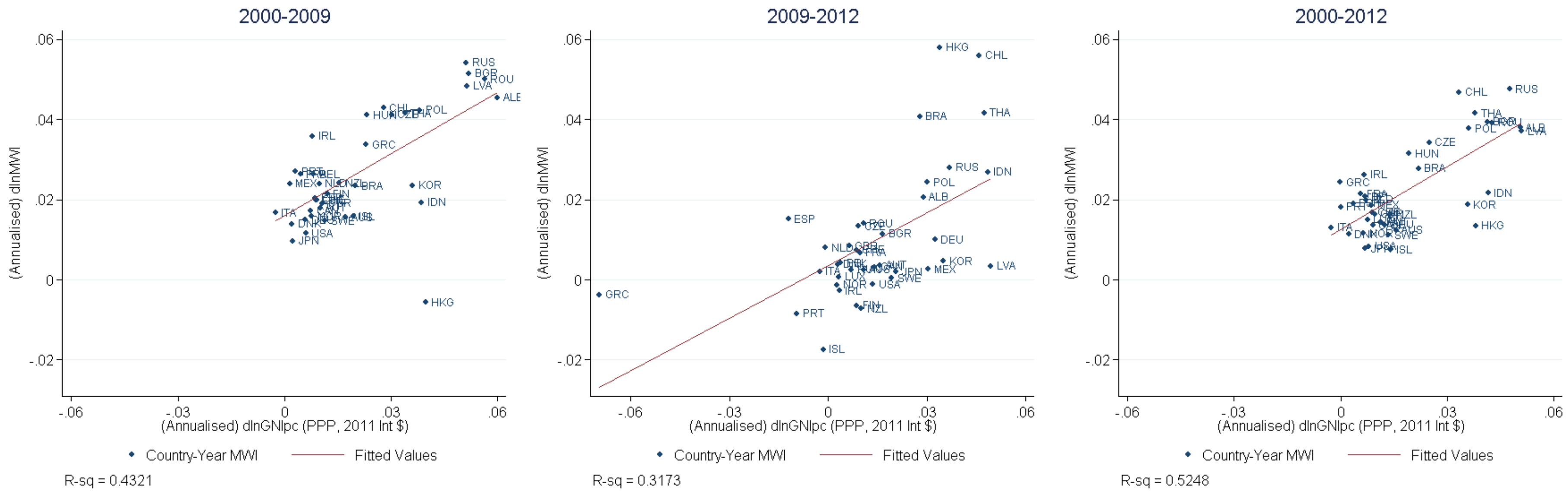
Box and whiskers are drawn as follows: the top and bottom of each solid box depicts the upper and lower quartiles of the relevant distribution, respectively; the band inside each box illustrates the median; whilst the whiskers represent the range between the upper (lower) quartile and the upper (lower) adjacent values, where adjacent values are defined as the highest (lowest) value not greater (less) than the upper (lower) quartile by 150% of the inter quartile range. Outside values, which are values that extend beyond the adjacent values, are not displayed.

Countries which administered the parental survey in 2009: CHL, DEU, DNK, HKG, HRV, HUN, ITA, KOR, LTU, MAC, NZL, PAN, POL, PRT, QAT. Countries which administered the parental survey in 2012: BEL, CHL, DEU, HKG, HRV, HUN, ITA, KOR, MAC, MEX, PRT.

Figure 3: Comparison of MWI and GNI per capita, by Year

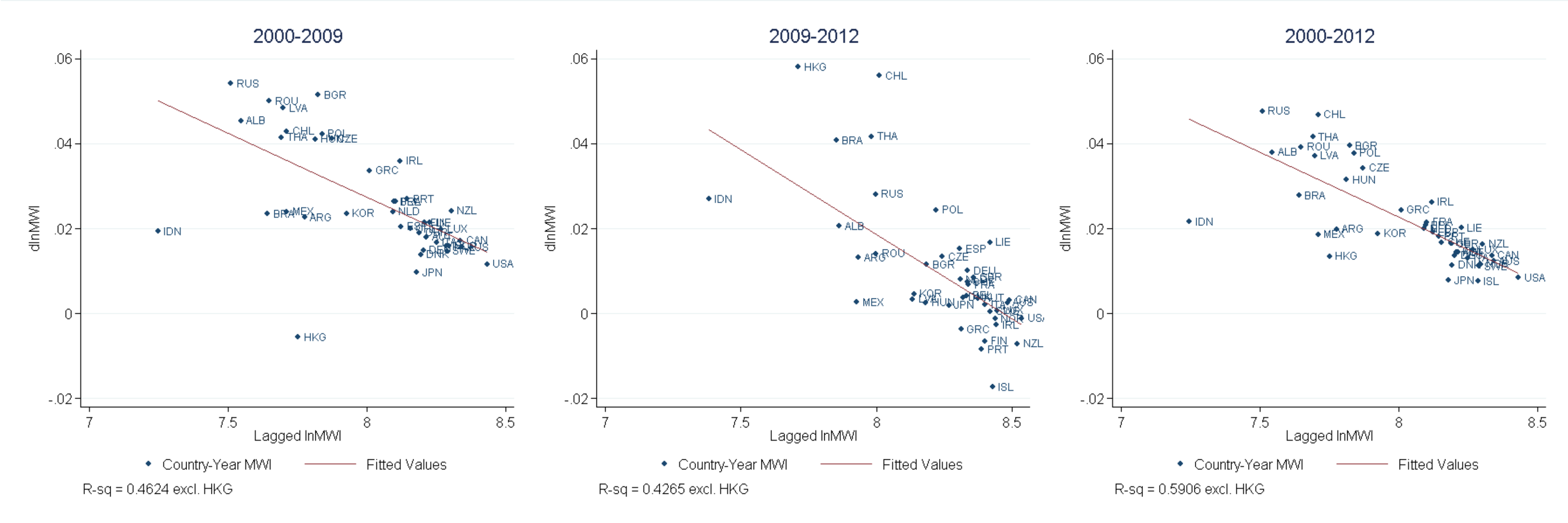
R-sq denotes the R-squared coefficient from a quadratic regression of lnMWI on lnGNIpc, from which the fitted values are obtained, where GNIpc is PPP-adjusted and expressed in 2011 International dollars. Note, whilst Hong Kong appears in the figure it is excluded from each regression as it is a strong outlier in the relationship between lnMWI and lnGNIpc.

Figure 4: Comparison of MWI and GNI per capita Growth Rates, by Period



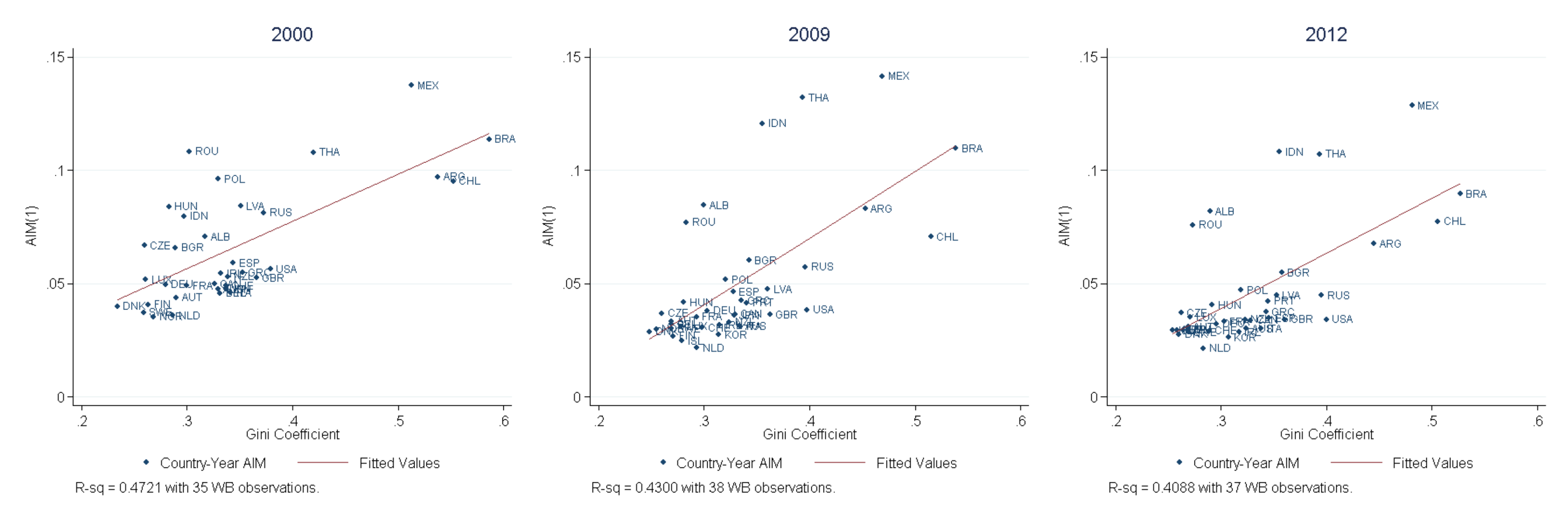
R-sq denotes the R-squared coefficient from a simple regression of dlnMWI on dlnGNIpc, that is, a regression of the change in lnMWI on the change in lnGNIpc over the regression period, from which the fitted values are obtained, where GNIpc is PPP-adjusted and expressed in 2011 International dollars. Note, whilst Hong Kong appears in the figure it is excluded from each regression as it is a strong outlier in the relationship between lnMWI and lnGNIpc.

Figure 5: Change in lnMWI and Lagged lnMWI Levels, by Period



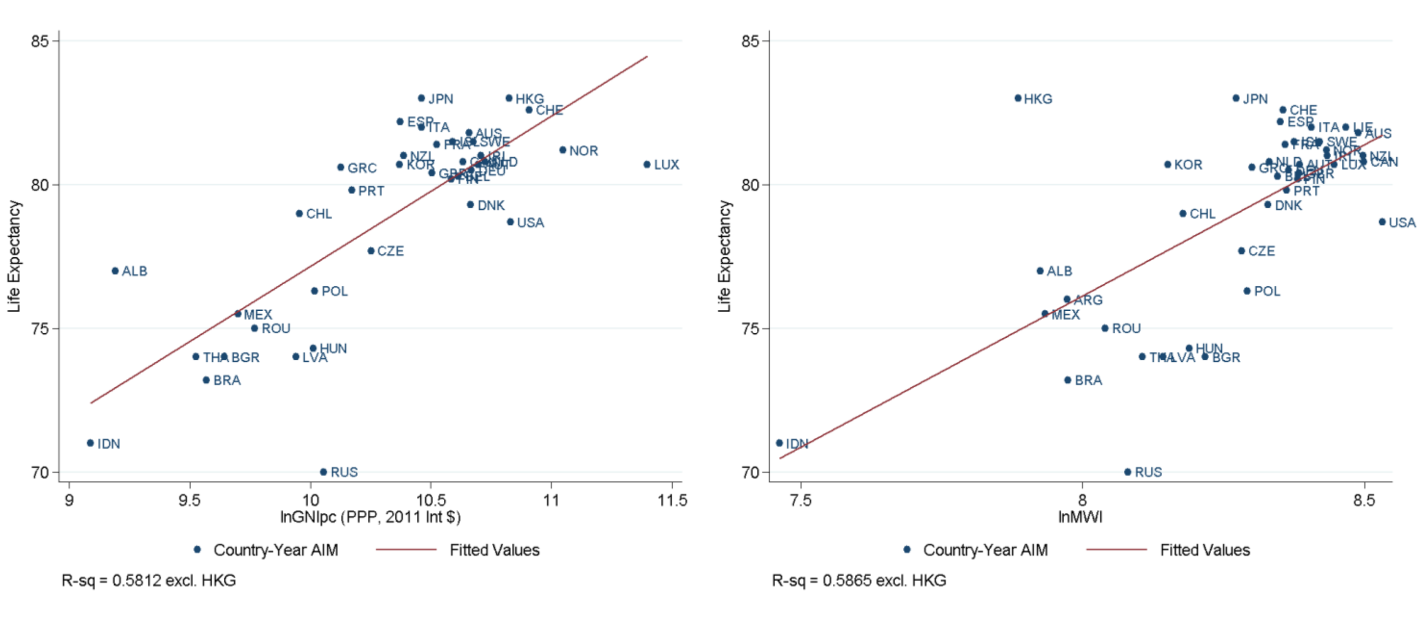
R-sq denotes the R-squared coefficient from a simple regression of dlnMWI on lnMWI, that is, a regression of the change in lnMWI over a period on the initial level of lnMWI, from which the fitted values are obtained.

Figure 6: Comparison of AIM(1) and the Gini Coefficient, by Year



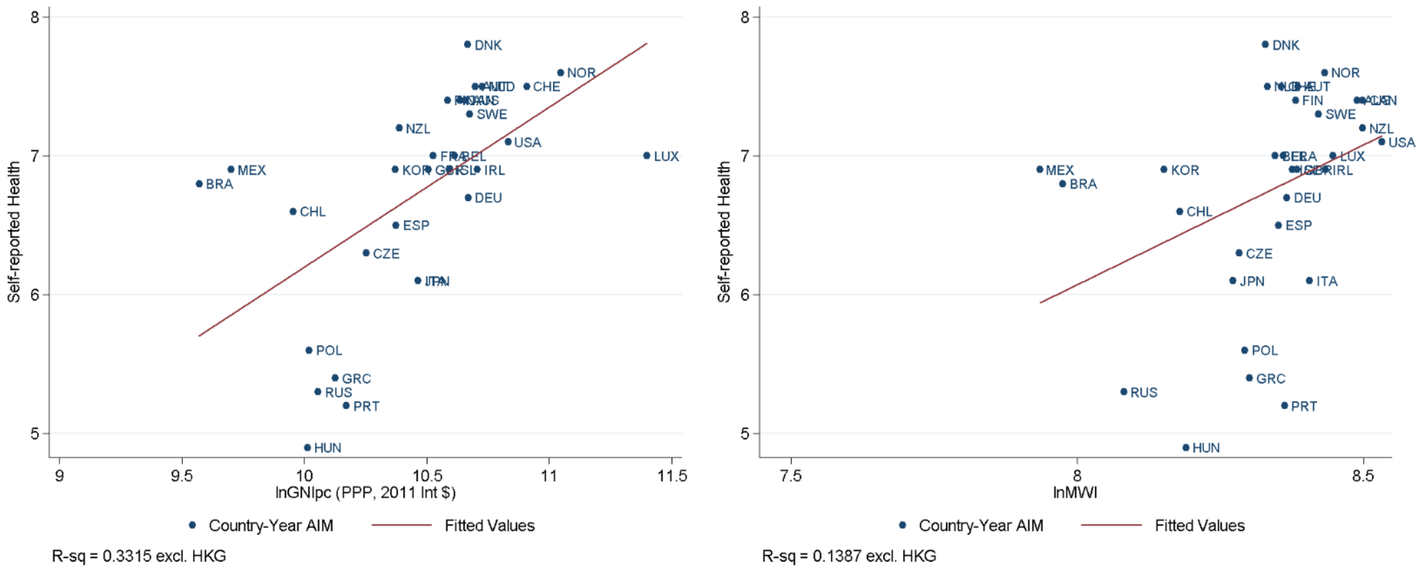
R-sq denotes the R-squared coefficient from a simple regression of AIM(1) on the Gini coefficient of household incomes that was obtained from a combination of World Bank and OECD data, from which the fitted values are obtained.

Figure 7: GNIpc and MWI vs Life Expectancy, 2012



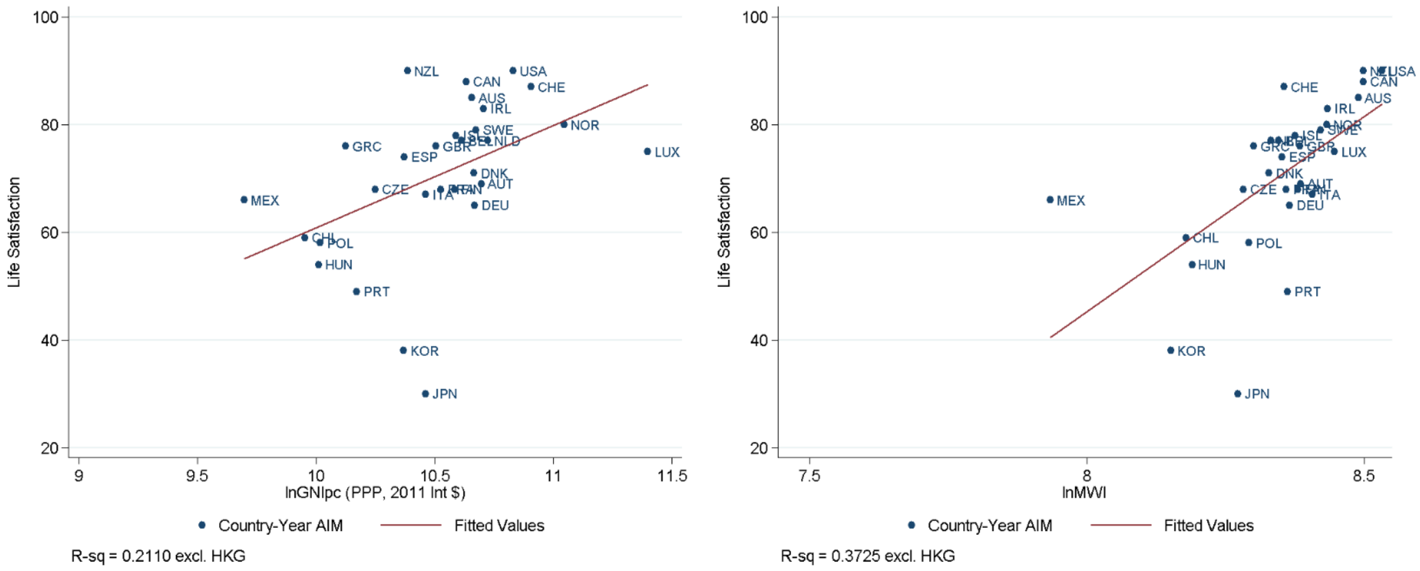
R-sq denotes the R-squared coefficient from a simple regression of either lnGNIpc or lnMWI on life expectancy, from which the fitted values are obtained.

Figure 8: GNIpc and MWI vs Average Life Satisfaction Score, 2012



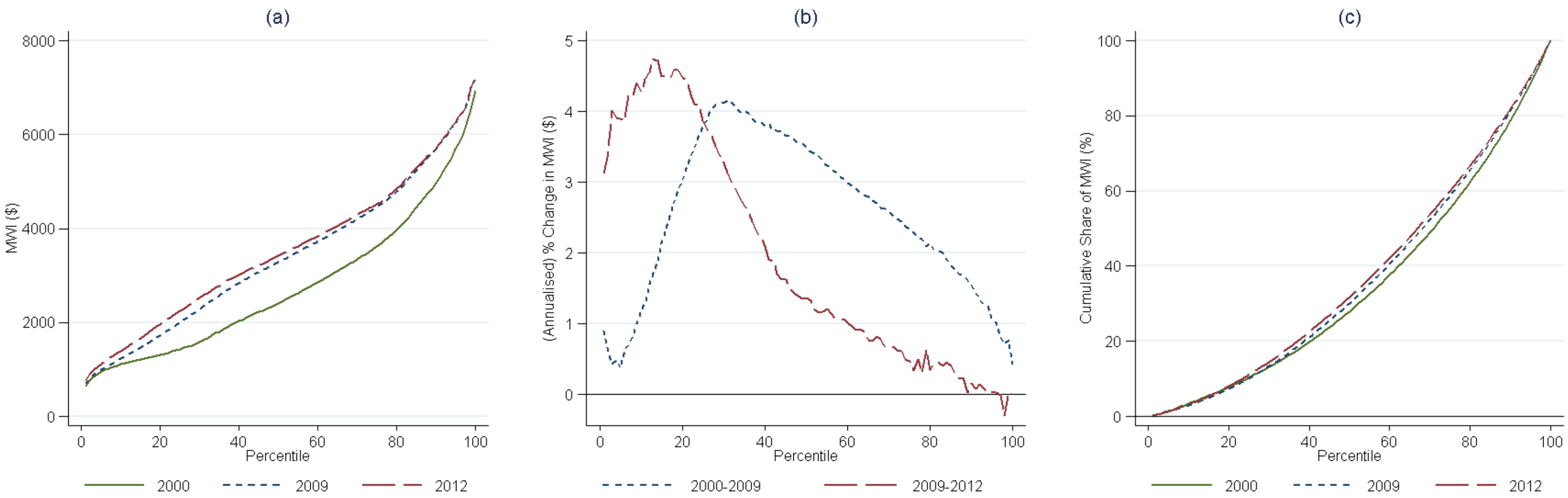
R-sq denotes the R-squared coefficient from a simple regression of either lnGNIpc or lnMWI on mean life satisfaction, as reported in OECD Better Life Index, from which the fitted values are obtained. The data source therefore restricts this analysis to developed countries.

Figure 9: GNIpc and MWI vs Average Self-reported Health Score, 2012



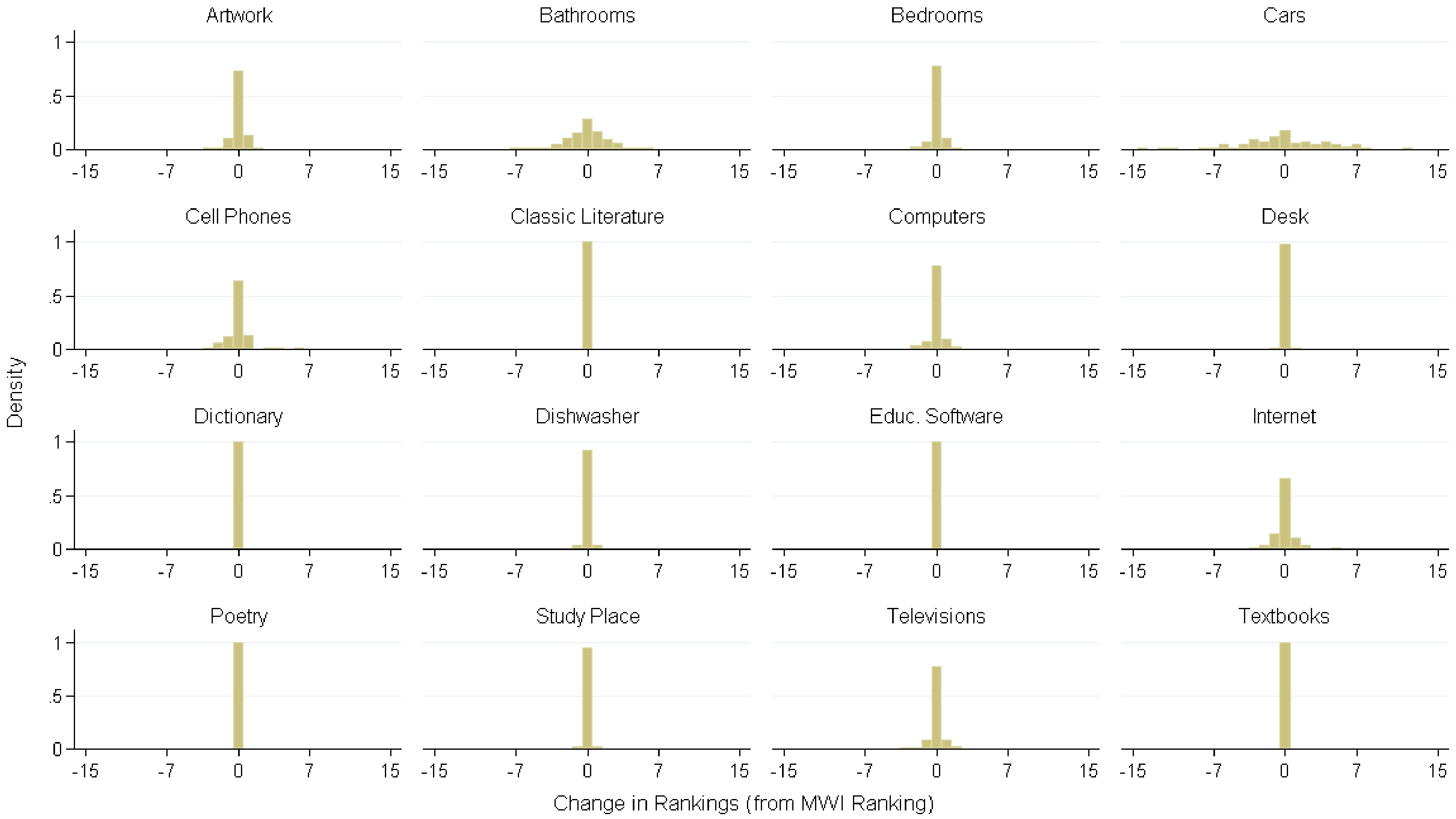
R-sq denotes the R-squared coefficient from a simple regression of either lnGNIpc or lnMWI on mean self-reported health, as reported in OECD Better Life Index, from which the fitted values are obtained. The data source therefore restricts this analysis to developed countries.

Figure 10: Attributes of the 'World' HMW Distribution



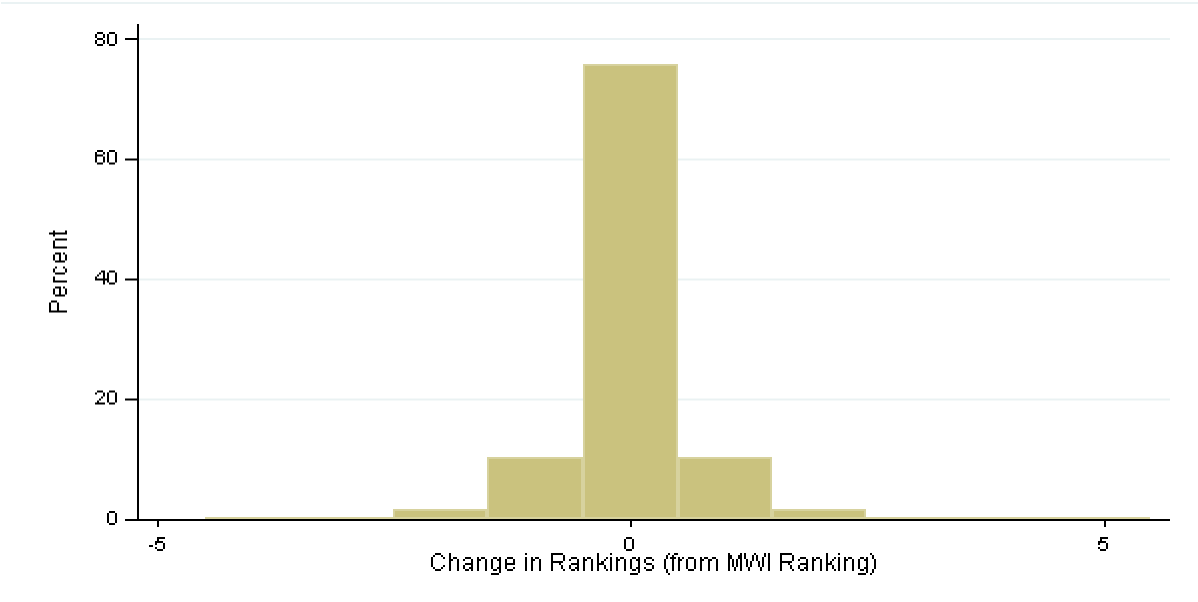
Panel (a) plots the level of HMW for each percentile of a 'world' distribution, developed by duplicating individual PISA observations by the ratio of their home countries population at survey time relative to PISA survey population. Panel (b) plots the annualised percentage change in HMW at each percentile over two periods, whilst panel (c) plots the 'world' HMW Lorenz Curve for each year.

Figure 11: Distribution of MWI and Excluded Possessions Pseudo-MWI Ranking Deviations, Pooled over Years, by Possession



The change in ranking for a specific country-year observation is defined as their year-specific Pseudo-MWI ranking (for a given omitted possession), less their corresponding MWI rank.

Figure 12: Distribution of MWI and Price Shock Pseudo-MWI Ranking Deviations, Pooled over Years and Repetitions



The change in ranking for a specific simulation-country-year observation is defined as their simulation-year-specific Pseudo-MWI ranking (for a given price shock vector), less their corresponding MWI rank.

Figure 13: A Comparison of MWI and Australian Expenditure Weighted Pseudo-MWI Rankings, by Year

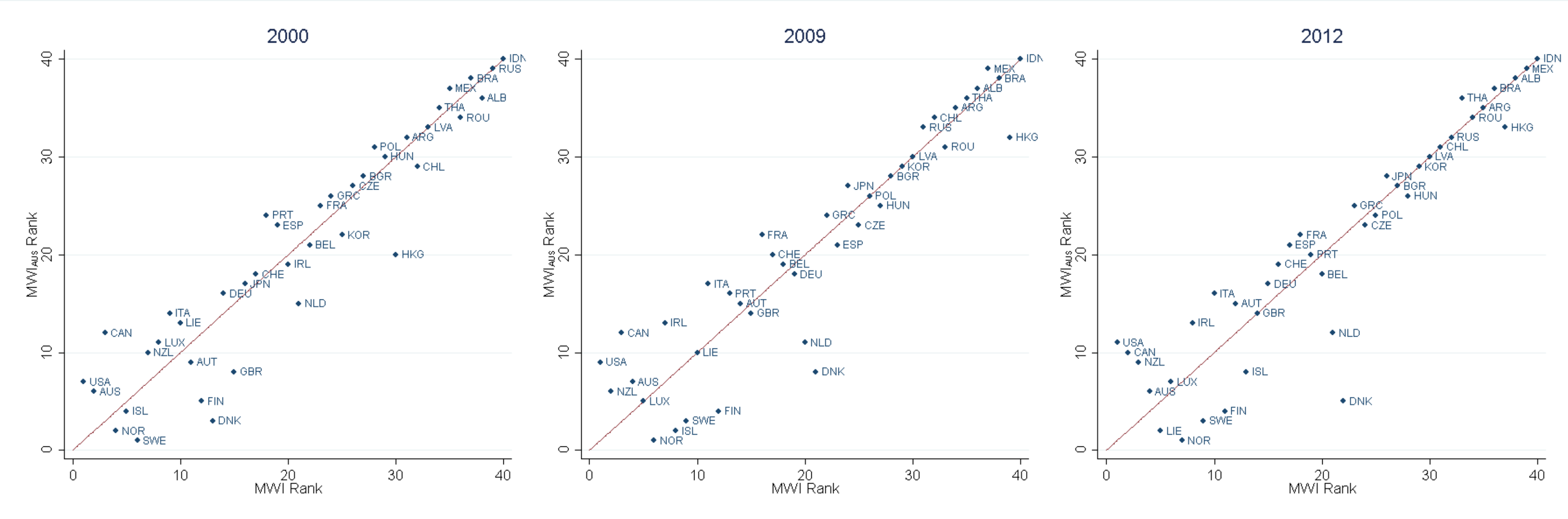


Figure 13 plots the ranking of country-year observations by MWI on the x-axis, and by the Pseudo-MWI that uses Australian expenditure weights on the y-axis - the 45° line depicted shows where rankings are equivalent across constructions.

Figure 14: A Comparison of AIM(1) and Australian Expenditure Weighted Pseudo-AIM(1) Rankings , by Year

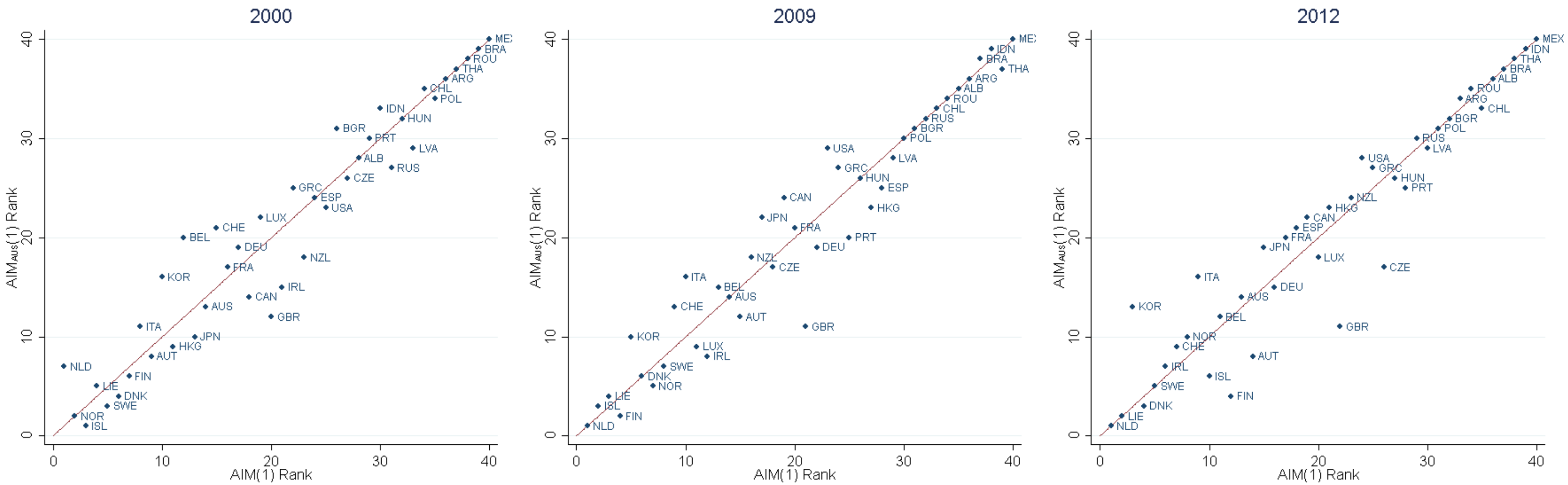


Figure 14 plots the ranking of country-year observations by AIM(1) on the x-axis, and by the Pseudo-AIM(1) that uses Australian expenditure weights on the y-axis - the 45° line depicted shows where rankings are equivalent across constructions.

Figure 15: A Comparison of IMWI(1) and Australian Expenditure Weighted Pseudo-IMWI(1) Rankings, by Year

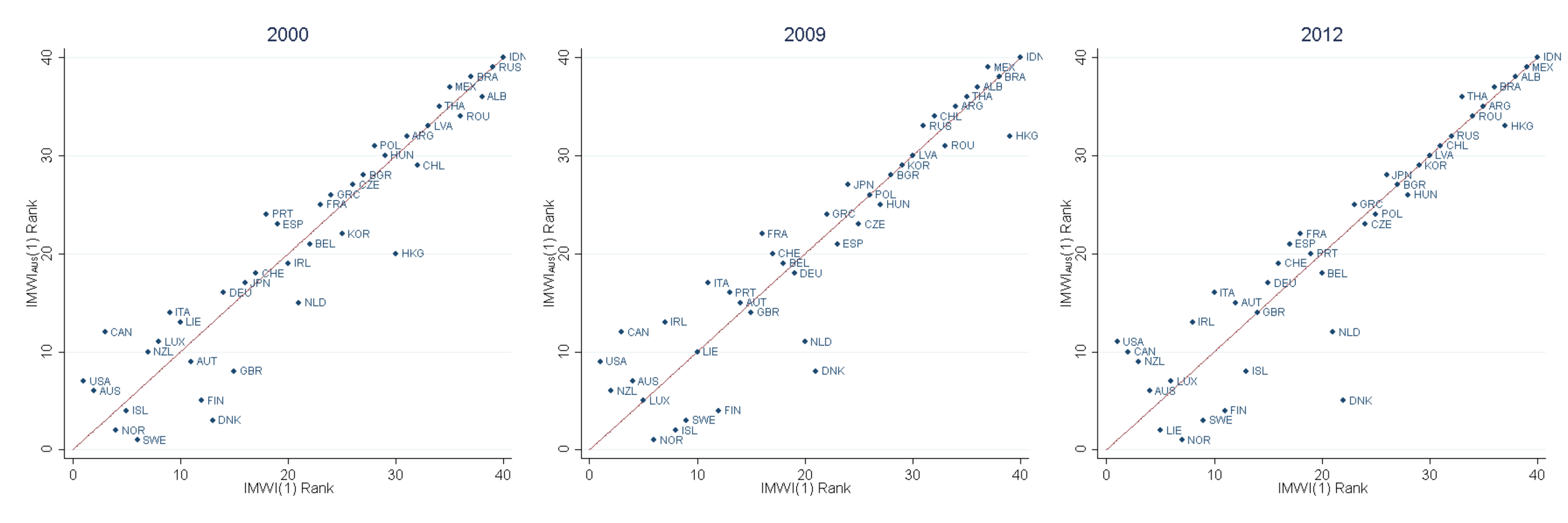


Figure 15 plots the ranking of country-year observations by IMWI(1) on the x-axis, and by the Pseudo-IMWI(1) that uses Australian expenditure weights on the y-axis - the 45° line depicted shows where rankings are equivalent across constructions.

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